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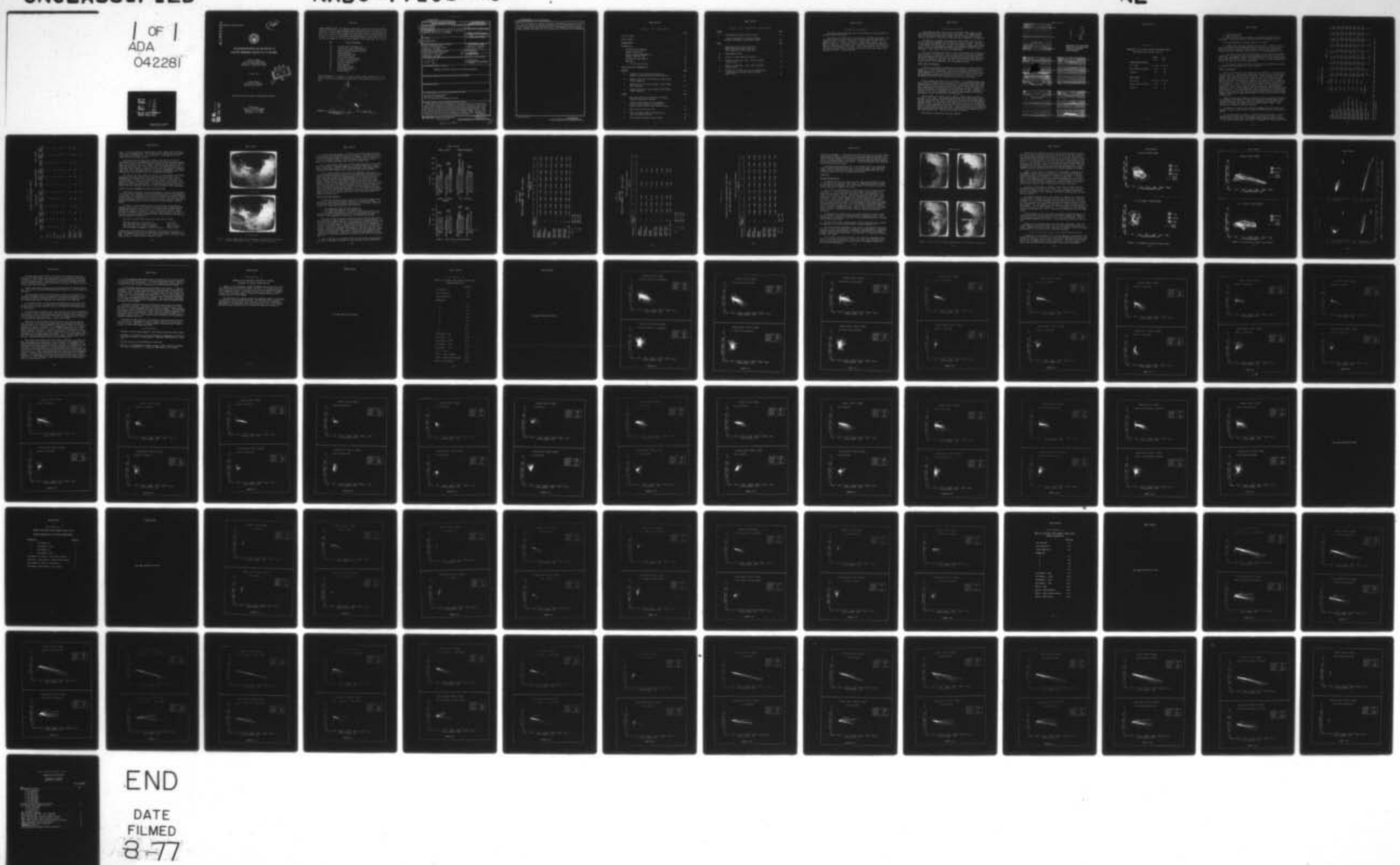

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ACCELERATION EFFECTS ON THE ABILITY TO ACTIVATE EMERGENCY DEVICES IN F-4 AIRCRAFT

Emma Fessenden
Crew Systems Department
NAVAL AIR DEVELOPMENT CENTER
Warminster, Pennsylvania 18974

11 JULY 1977

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Experiments have been performed and are described in this report which measure the influence of environment on the time it takes to reach an emergency control activation device and which measure the change of physical position at the time of activation due to the environmental forces. Data are reported for both loose and tight torso harness straps. Minus Gx and minus Gz are identified as the components of various likely emergency environments which cause pilots the greatest difficulties. (Continued) next page

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20. The contribution of combined individual anthropometric measures has been identified as having very pronounced influence on the reachability of certain control devices under specific environments. Improvements in existing seat harness systems and testing for future systems to be developed are recommended.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

A C K N O W L E D G M E N T

The labors of many individuals went into producing the material which is described within this report.

The study was conducted under the sponsorship of NAVAIR (Code 340B). The centrifuge facilities staff headed by Mr. William Daymon included Messrs P. Edwards, R. Hall, D. Kiefer, L. Burkett, J. Murray and K. Scholl. Dr. M. Cohen and Messrs R. Crosbie and J. Horan reviewed and edited the manuscript. Messrs R. Zabelicky, J. O'Rourke and L. D'Aulerio contributed the figures and computer display programs of the data. Much of the credit for this successful venture is due to their excellence and to the valiant Navy subjects who performed willingly to create the data.

INTRODUCTION

Aircrewmen have been and are being killed because they cannot activate the proper emergency device under adverse conditions. The crewmen must be able to reach and activate their emergency control devices under the wide range of accelerative conditions to which they may be exposed in an emergency.

The ability of a crewman to activate the control which sets into operation his emergency equipment can be dependent on several factors: the size of the crewman, the type of seat, the restraint harness he wears, the location of the control for the emergency equipment, the physical configuration of the control, and the acceleration environment under which the control is being activated. These factors may also be interdependent.

This study culminates an effort to assess the importance and influence of these factors and to introduce a logic by which these factors may be weighed and to introduce guidelines to enable the comparison of the effectiveness of the control devices with the seats and under the environments that are present in aircraft emergency situations. The final result will yield more satisfactory systems with minimum delays to the emergency devices.

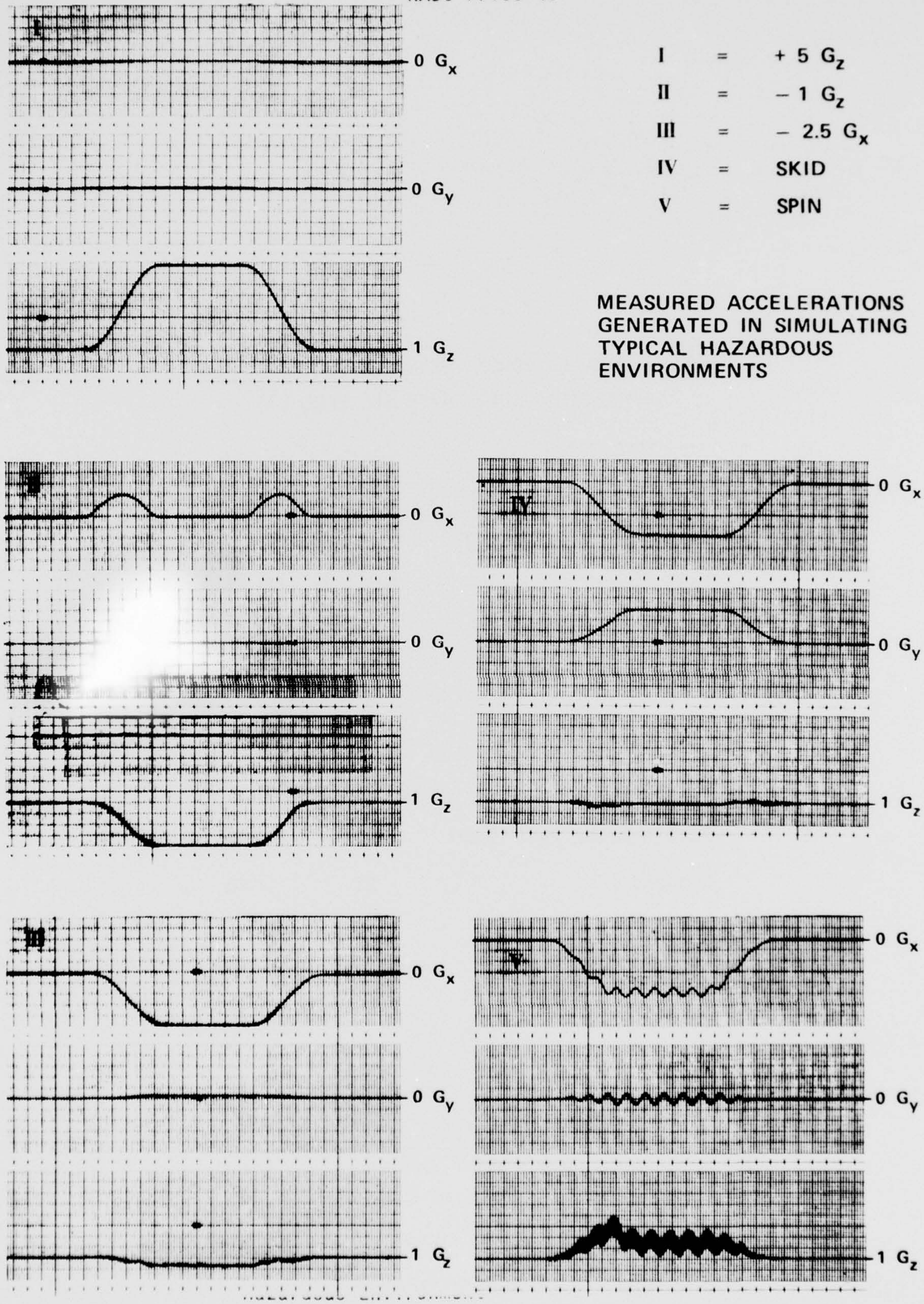
INVESTIGATIVE METHODOLOGY

A series of experiments was designed and performed to reveal differences existing in current systems and to uncover areas in which improvements are deemed more critical and feasible. Realistic environments which do occur in flight emergencies (1) were programmed for the dynamic flight simulator (DFS). The experiments reported here were patterned after those reported (2); only the details that differ from the previous report will be given here.

Certain changes were made in the environments. To accommodate more conditions, those environments which had little or no significance were dropped and replaced by more severe or other representative accelerative conditions. Spin was increased in severity and post-stall gyrations and buffet were replaced by forces representing a skidding (either air or ground) aircraft. Figure 1 is an actual recording of the measured accelerations used in these experiments in terms of Gx, Gy, and Gz components that comprised the emergency environments developed for use in the experiments detailed herein.

The F-4 cockpit was used as a base; however, a Martin Baker Seat MK-H/7 was used in this study. (An ESCAPAC seat had been used in the previous report.) The face curtain and lower ejection handle were outfitted with microswitches to indicate operation of the control device detent and the end of the pre-ejection sequencer (fire). Once more, the drag chute actuator was used as a representative of a side arm emergency control and the stores release button as a possible control located forward on the side panel. The forces necessary to activate the lower ejection handle and the face curtain were measured and compared with military specifications (3). These forces are given in table I.

The following criteria were used for judgment:



MEASURED ACCELERATIONS GENERATED IN SIMULATING TYPICAL HAZARDOUS ENVIRONMENTS

TABLE I

COMPARISON OF PULL FORCES MEASURED FOR MARTIN BAKER AND ESCAPAC SEATS WITH MIL SPEC (3)

	Detent (lb)	Fire (lb)
Lower Ejection Handle		
Mil. Specs	15 to 25	30 to 40
Martin Baker Seat MKH/7	18.5	47
Escapac I	15	40
Face Curtain		
Mil. Specs	20 to 40	30 to 40
Martin Baker Seat MKH/7	22.5	39
Escapac I	25	40

1. ability to reach,
2. time to reach, and
3. body position due to environment at the time of decision (in this experiment, a light and noise) to activate the ejection/emergency control.

The following general assumptions apply to this study:

1. Crewmen and pilots have equatable reaction times. Crewmen as well as pilots are required to take emergency actions. Ejection seats are a requirement in the Navy's inventory of specialized aircraft such as the EA6B and S3A (both have four ejectable seats) as well as in high performance aircraft.

2. The subject volunteers are representative of the entire pilot-crewman population. The subjects used in these experiments span the 3rd to 98th percentile (4) anthropometric range. The qualifications for their ratings include mental abilities similar to those of aircrewmen. Table II shows anthropomorphic data on the subjects used in this experiment.

3. The current subjects and those of the previous experiment were equally motivated and have equivalent skills and training.

GENERAL OBSERVATIONS

Prior to any activation, the control must be reachable. The subjects were placed in the seat. The seat was adjusted as close as possible to the design-eye position as recorded in aircraft drawings. Certain surprising facts were evident. The stores-release button on the left side of the front instrument panel was not reachable at all by a segment of the subjects when the torso harness was tight. This button was reachable with difficulty by the remainder of the subjects. Thus, to operate the stores release button, the pilot of the F-4 requires loose straps. This factor was discussed with and confirmed by current F-4 pilots. The failure to reach this button was correlated with a combination of short sitting height (>20 percentile) and a short extended reach (>15 percentile). One individual with a short extended reach (1st percentile) whose sitting height was tall (70th percentile) could reach this stores release button, reinforcing the combined requirement of short sitting stature and short extended reach.

Table III gives the incidents of failure to reach the controls according to the detrimental environments for both the Escapac and the Martin Baker seats. In the Martin Baker seat (this report) the experiment was conducted, where possible, with both tight harness straps and loose harness straps. These results are included for comparison purposes.

The harness and inertia reel, which are integral parts of the seat, may operate in either a loose strap or a tight strap mode according to the pilot's option.

In the tight mode, the subject is held rigid to the seat back. If he is leaning forward at the time the tight mode is selected, he remains in this position until he moves back. Any backward motion, however, sets the harness in a new tight position until the subject is eventually all the way back in the

TABLE II

ANTHROPOMETRIC DATA

	3%	98%	1	2	3	4	5	6	7	8	10
			SUBJECT NO.								
Weight (lb)	136.24	213.47	139	180	175	172	140	129	204	147	180
(percentile)			(5)	(70)	(66)	(50)	(5)	(1)	(95)	(10)	(70)
Height (in)	65.79	74.78	68.3	67.8	71.3	71.0	66.6	67.75	71.25	67.0	72.0
(percentile)			(25)	(20)	(70)	(70)	(7)	(20)	(70)	(10)	(70)
Sitting Height (in)	33.96	38.9	34.8	35.5	38.2	37.0	35.6	35.5	37.25	37.0	35.5
(percentile			(15)	(25)	(90)	(70)	(30)	(25)	(80)	(70)	(25)
Eye Height Sitting (in)	29.41	34.16	30.5	32.25	33.6	33.2	30.8	32.0	32.5	31.1	33.5
(percentile)			(20)	(70)	(95)	(70)	(25)	(65)	(80)	(35)	(95)
Shoulder Height Sitting (in)	21.81	26.02	23	24.7	24.7	25.2	23.5	24.9	26.9	24.6	25.0
(percentile)			(25)	(80)	(80)	(90)	(40)	(85)	(99)	(80)	(85)
Shoulder Elbow Length (in)	13.26	15.91	14.5	14.3	14.0	14.75	14.0	14.6	15.5	12.5	14.0
(percentile)			(55)	(40)	(25)	(65)	(25)	(55)	(95)	(1)	(25)
Forearm-Hand Length (in)	17.75	20.64	18.25	18.25	19.25	17.75	17.25	17.5	20.25	18.5	18.0
(percentile)			(15)	(15)	(60)	(3)	(1)	(1)	(95)	(20)	(5)
Functional Reach (in)	29.07	34.7	31.5	33.9	31.5	31.25	30.0	24.3	33.0	29.0	28.0
(percentile)			(55)	(95)	(55)	(45)	(15)	(5)	(85)	(3)	(1)
Seat Adjustment (in)	All Way Up 0	6	5.25	6	6	6	6	6	6	6	6
Eye Level*			0	+1	+1	+0.5	0	+0.5	+1	0	+1

*Inches above design eye: Note - no one is lower than design eye; experimental eye level range is 20 ⟶ 75 percentile.

TABLE III

FAILURES TO REACH EMERGENCY CONTROLS

	DRAG CHUTE			STORES RELEASE			LOWER EJECTION HANDLE			FACE CURTAIN		
Env.	Escapac (Tight)	Martin Baker (Tight)	Martin Baker (Loose)	Escapac (Tight)	Martin Baker (Tight)	Martin Baker (Loose)	Escapac (Tight)	Martin Baker (Tight)	Martin Baker (Loose)	Escapac (Tight)	Martin Baker (Tight)	Martin Baker (Loose)
+5 Gz	0	0	0	0	2	0	0	0	0	0	0	0
-1 Gz	0	0	-	5	4	-	1	0	-	0	2	-
-2.5 Gx	0	0	0	0	3	0	0	0	0	2	1	5
Spin	0	0	0	0	3	0	0	0	0	0	0	5
Skid	-	1	0	-	3	0	-	0	0	-	0	5
Normal	0	0	0	0	3	0	0	0	0	0	0	0
Total # of Failures	0	1	0	5	18	0	1	0	0	2	3	15
Total # of Trials	35	54	25	35	54	25	35	54	25	35	54	25
Total # of Subjects	7	9	5	7	9	5	7	9	5	7	9	5

seat. In the loose mode his straps extend to such a degree that his head can contact the instrument panel. If the strap pulls on the inertial reel under a fast-onset acceleration of 2 to 3 G, the reel is activated to pull the subject back to the tight position.

Experiments with the loose strap condition were not run in the -1G environment since this environment was achieved by turning the subject upside down. An inflatable collar was required to be worn by the subject to provide additional support to the neck. Figure 2 shows the subject ready for the tight and loose strap runs. After a few runs it was discovered that the face curtain was out of reach for subjects in a strong -Gx environment. Therefore, under loose straps conditions, the face curtain was eliminated in the -2.5 Gx, skid and spin; all of which have -Gx as an important constituent.

The subject with loose straps was subjected to the hazardous environment generated by the same profiles (see figure 1) used for the tight straps. Although values in excess of 3G were achieved, the pull on the straps was not sufficient to activate the automatic locking device. Situations of this nature are common in aircraft flight. The presence of the neck collar on the subject did offer some interference. It tended to provide support for the head in the +5Gz experiment, thus restricting head motion in this environment.

EFFECT OF DEVICE/ENVIRONMENT ON CONTROL ACTUATION TIMES

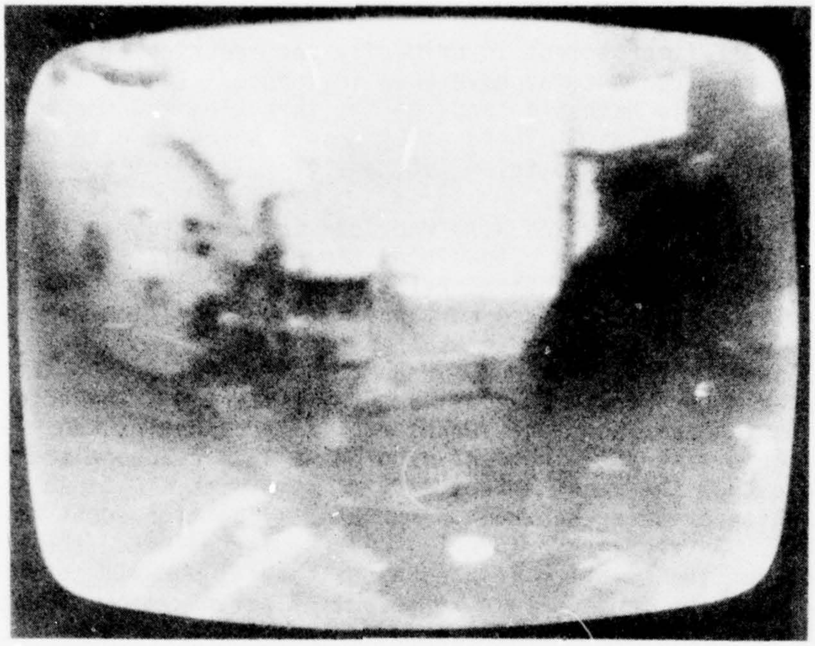
Under normal conditions, it takes approximately 1 second, after the decision to activate an emergency device has been made, until the firing mechanism is initiated. This time delay results from the completion of several necessary events and may be influenced by the shape and location of the particular device and the environment in which the action must take place. Thus the times which measure the action become a criteria to measure the environmental or device effect.

In flight the pilot (crewman) makes his own decision to activate the emergency device; this study assumed that the decision had already been made and examined responses from that point. A combined light and noise signal alerted the crewman to activate his control as quickly as possible. Microswitches in the cockpit indicated the crewman's hand position at the time of the light activation, when he removed his hands, when the detent released, and final activation of the control.

The time to activate each control was broken down as follows:

Time from light/noise on to hands off;	"on to Hoff"
Time from hands off to device activation;	"Hoff to off"
Time from hands off to detent disengaged;	"Hoff to detent"
Time from detent disengaged to device activation;	"Detent to off"

In each case a microswitch gave an indication of the state of the action. In each time segment the physical environment may be detrimental, beneficial or both. As an illustration of this point, when inverted (-1Gz), the face curtain might be easier to reach but more difficult to pull.



A - Straps Tight

B- Straps Loose

FIGURE 2 - Subjects (Under Normal $1G_z$ Environment) in their Initial Positions: (a) With Tight Harness Straps; (b) With Loose Harness Straps.

The ON TO HOFF time segment is primarily the reaction time of the individual; however, environment may have some influence. The initial position required the subject to have his hands on the throttles and the control stick as a pilot must do in flight. Those environments which tend to press his hands to the controls may lead to an increase of release time.

Not all the controls, which were required to be activated in this experiment, had a detent. In making comparison, the HOFF TO OFF times of those controls which had no detent (stores release and drag chute) were compared with the HOFF TO DET times of face curtain and lower ejection handle.

Figure 3 shows the mean values for On to Detent/Off across all the subjects grouped according to the device to be activated. The effect of the environment and the type and location of each control device can easily be seen. Under the ordinary environment (denoted as 1G), reaching the lower ejection handle took the least amount of time both with tight and loose straps. The white area in each column represents the time spent in going from Det to Off. As reported before (2) and reinforced here, the pull of the lower ejection handle, as noted in the Detent to Off, shows much more variation in time while the face curtain, once out of detent, shows a uniform, consistent time to complete the activation. This is in spite of the rather long travel of the face curtain compared to the travel of the lower ejection handle. This area is certainly one in which better engineering might well produce positive results.

REACTION TIME DATA ANALYSES

The data of the various reaction times were collected and analysed for statistical significance according to analysis of variance techniques. In an experiment which involves people, data points will be missed. Among the reasons for missing data points were the following:

1. The subject was unable to reach the device,
2. The experimental data was not readable, and
3. The subject was delayed in reaching the activation device by such unrelated factors as mechanical failure of the experimental equipment not relevant to the experimental design; hence the time was unduly long.

Inclusion of these artifacts as data points would statistically obscure any significant change of time for either the device or the environment. To facilitate the statistical analysis, a value must be inserted for the missing or obviously erroneous point. If the remaining data are to be meaningful, the missing data point must be inserted so as to have little influence on the results. Therefore, an average of the subject's baseline 1G runs for that particular device was selected. The influence on the null theory was towards a type-1 error which would lead toward a conservative determination of the statistical significance. Tables IV, V, and VI show the computed F ratios and degree of significance which may be attached to this point of the experiment.

Only in the case of two subjects with the tight harness strap condition was there a significant difference of time resulting from the detrimental

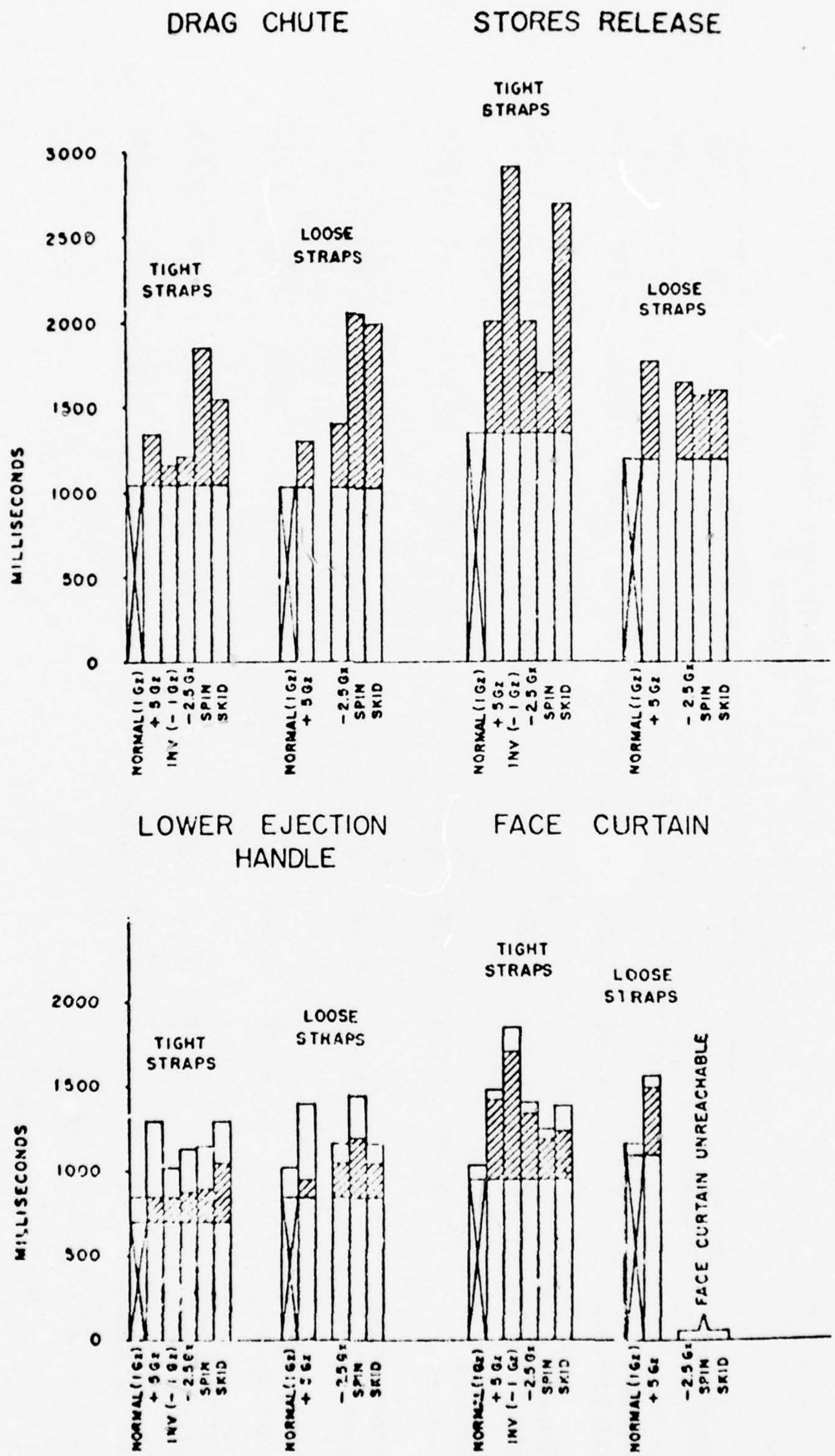


FIGURE 3 - Mean Values of Reaction Times.

TABLE IV

TIGHT STRAPS

ANALYSIS OF VARIANCE - TIME - HOFF TO DET/OFF

F Ratio for Individual Subjects

Conditions	Degrees of Freedom	Subject # 1	2	3	4	5	6	7	8	10
Between Repetitions	1	7.700	0.002	0.278	7.418	0.240	0.433	0.566	2.038	0.363
Between Environments	5	1.039	1.368	1.387	4.144	0.094	2.088	2.960	1.214	2.868
Between Devices	3	3.016	2.530	3.348	11.147	16.979	8.828	10.779	13.097	10.894
Interaction: (Rep x Env)	5	0.883	0.604	0.842	2.122	1.414	1.208	0.126	1.500	1.162
Interaction: (Rep x Dev)	3	0.728	0.643	0.048	1.622	0.764	1.035	0.336	2.095	0.050
Interaction: (Env x Dev)	15	1.376	0.547	1.540	1.552	0.528	1.458	2.540	1.220	2.222
Rep x Env x Dev	15	0.211	0.773	0.900	0.129	0.936	0.133	0.113	0.224	1.245

df = 1 $F_{95} > 4.54$

= 3 $F_{95} > 3.29$

= 5 $F_{95} > 2.90$

= 15 $F_{95} > 2.40$

TABLE V

LOOSE STRAPS

ANALYSIS OF VARIANCE - TIME - HOFF TO DET/OFF

F Ratio for Individual Subjects

Conditions	Degrees of Freedom	Subject # 1	2	3	4	5	6	7	8	10
Between Repetitions	1	0.268	0.363	2.086		0.206		0.451		
Between Environments	5	0.834	3.649	5.218		1.783		2.716		
Between Devices	2	1.004	99.624	10.159		21.515		3.872		
Interaction: (Rep x Env)	5	1.042	2.160	1.457		0.150		0.798		
Interaction: (Rep x Dev)	2	1.322	2.504	0.703		0.358		1.583		
Interaction: (Env x Dev)	10	1.069	3.250	5.367		0.783		0.780		
Rep x Env X Dev	10	1.493	0.057	0.246		0.097		0.137		

$df = 1 \quad F_{95} > 4.96$
$= 2 \quad F_{95} > 4.10$
$= 5 \quad F_{95} > 3.33$
$= 10 \quad F_{95} > 2.98$

TABLE VI

AN ANALYSIS OF THE SLIDING MECHANISM OF FACE CURTAIN

AND LOWER EJECTION HANDLE (DET TO OFF)

Conditions	Degrees of Freedom	F Ratio for Individual Subjects — Subject # 1	2	3	4	5	6	7	8	10
Between Repetitions	1	1.383	0.072	1.436	2.261	2.999	1.013	3.530	4.925	1.964
Between Environments	5	0.889	1.683	1.108	3.746	1.755	2.815	1.173	1.336	0.918
Between Devices	1	2.543	23.635	0.463	31.235	70.003	7.064	4.122	5.056	0.188
Interaction: (Rep x Env)	5	1.620	0.770	1.091	1.144	1.146	1.404	0.969	0.832	1.824
Interaction: (Rep x Dev)	1	0.604	0.018	0.666	2.552	4.013	3.153	3.773	3.745	0.977
Interaction: (Env x Dev)	5	1.930	1.284	1.060	2.826	1.701	4.728	1.076	0.676	1.392

df = 1 $F_{95} > 6.61$

df = 5 $F_{95} > 5.05$

effect of environment. In the Escapac seat there were five out of seven showing significant detriment as a result of the adverse environmental condition. All significance was judged at the 95 percent confidence level for positive significance. In contrast seven of nine subjects responded significantly different to the character and location of the device. In the loose harness strap condition, similar observations are noted.

From the previous experiment (2) on the Escapac seat, it was determined that environment contributed to delays in activation rather than the device sought. Thus, it seems that the system should be examined rather than the individual items to arrive at optimum (least) delays.

VIDEO DATA

Position Determination

In addition to the time of reaction data, data of body position (or out of position) of the subject at the instant of command by the light to reach for the device, was recorded. Thus, environmental contributions to reaching difficulties were included in this study.

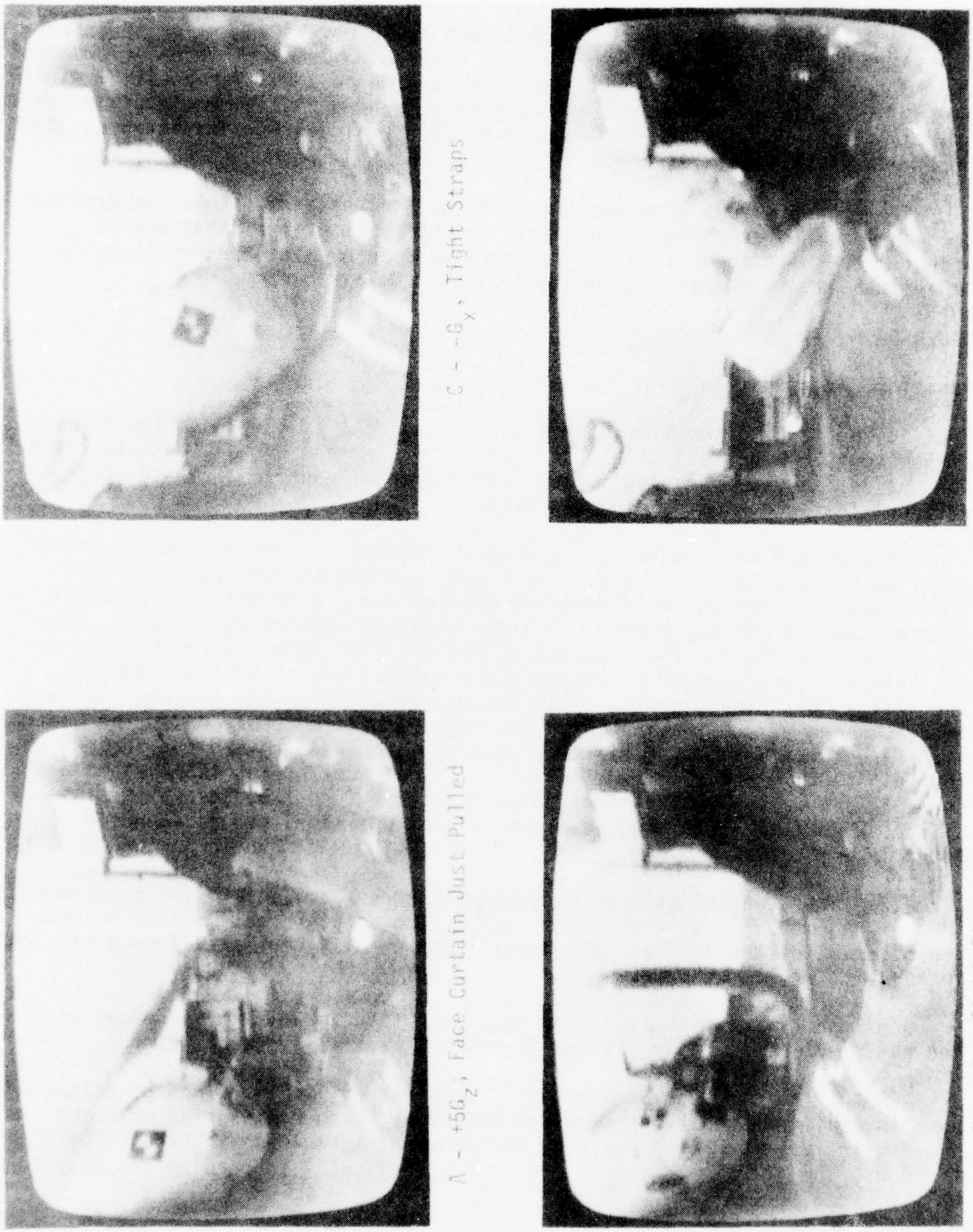
This record was determined by a unique method. Prior to running of the experiments, a 1-inch screen was built and inserted in the cockpit. This screen was pictured on the video tape monitor and a grid constructed as an overlay for the monitor screen. A video tape was made of the trials. Each subject wore a small target (patch) on his shoulder bone protrusion and on his helmet. These served to indicate the initial position of the subject. The initial position of the subject was marked and then the new position was read as x and y from the initial. The requirement to firmly grasp the control stick and throttles at the start of each run tended to return the subject to the initial position after each trial. Typical "Out of Position" views are shown in figure 4. Observations taken from the video tape on the consistency of the subjects in returning to their initial positions can be found in Appendix A.

The camera was aligned with the lens surface parallel to the X-Z plane through the man. Thus, when a combined motion is achieved, such as a turn, the movement of the head in rolling will not be differentiated from a straightforward motion of the head.

The use of the overlay method negated artifacts which would occur within the equipment itself, such as non-linearity, camera alignment, etc.

One of the distinct advantages of this rather simple method of detecting position shift was that there was no apparatus, either measuring or supporting a measuring device, which would by its presence interfere with the subject's freedom. The greatest disadvantage is the difficulty in reading the position on the video screen.

The position of the target mounted on the subject was determined with a degree of accuracy of ±0.5 inch. The data were fed into a computer so that they could be group according to subject, device, environment, repetition, or any desired combination.



A - $+5G_z$, Face Curtain Just Pulled

B - $-G_z$, Tight Straps

C - $-G_x$, Tight Straps

D - $-G_x$, Loose Straps

FIGURE 4 - Views of Subjects under Environment at or Just After Activation Cue.

The data were printed out as lines from the origin (subject's initial position) to the x, y position where the subject was at the time of reaching for the designated emergency control device. This line does not indicate the path the subject followed in reaching the position but is rather a vector from origin to end position. The original position is designated as a small plus (+). A circle drawn about this plus sign would roughly approximate the accuracy of the readings. Zero or no movement has been eliminated from the plotted data to give an increased clarity to the remaining lines. Using the outermost lines in forming an enclosure developed an envelope which represented the possible positions resulting from a chosen grouping of the data.

Figure 5 is the result of examining all the variables; sweeping across environment, device, subject, and repetition. The distinct contribution (envelopes) of the five environments considered in this report is shown in figure 5 outlined by a combination of striping and stippling. It is noted that the multicomponent skid and spin envelopes encompass an area outside those of the single-component environments. Forward movement of the head of from 10 to 12 inches was not uncommon even though the straps of the torso harness which held the subject in place were as tight as possible.

To assess the influence of tightness of the harness straps, position measurements were also made with the loose strap. Figure 6 gives the total position environment (straps loose) for the four environments considered, with the contribution of the individual environments represented by the same coding as figure 5.

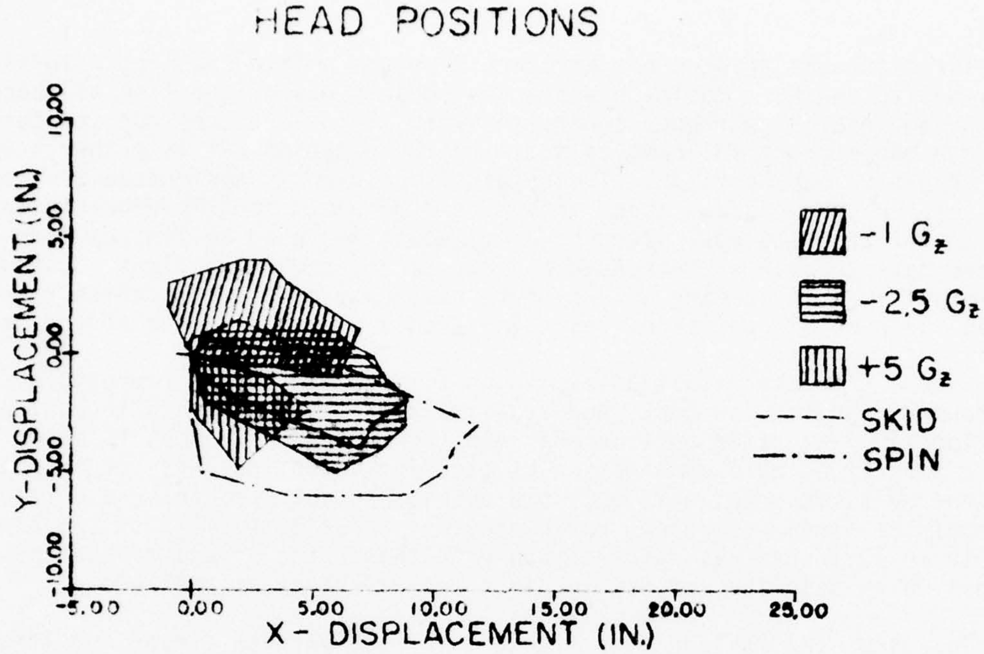
The support provided by the tight harnesses is dramatically illustrated in figure 7 which compares the tight and loose positions for the -2.5Gx environment only. In those environments which contain the strong -Gx, the head is near or resting on the instrument panel when the harness straps are loose, thus representing the extreme position achieved in those relatively "mild" environments. This Gx movement could be partially resisted (as did subject #3) if the subject is not caught unprepared. All the groupings of the video data are given in Appendices B, C and D. There were no negative Gz runs with loose straps.

The environment to which the subject was exposed contributed much to his change of position prior to reaching for the device. However, the identity of the devices to be actuated exerted little or no such influence. There is some shoulder movement by the subjects in anticipation of face-curtain activation.

Comparison of individuals does show distinctive differences. Some individuals seem to repeat their behavior very well while others deviate from run to run. Appendix C gives the tight strap data for subjects 1 and 3 for specific enfironments in illustration of this individual variation.

CONCLUSIONS AND RECOMMENDATIONS

A comparison of the reachability to various emergency control devices from the Martin Baker seat reveals that the lower ejection handle and the drag chute handle are, in general, the most easily accessible. The stores release button on the left instrument panel is often inaccessible. The face curtain also is found to be inaccessible under many emergency accelerative environments.



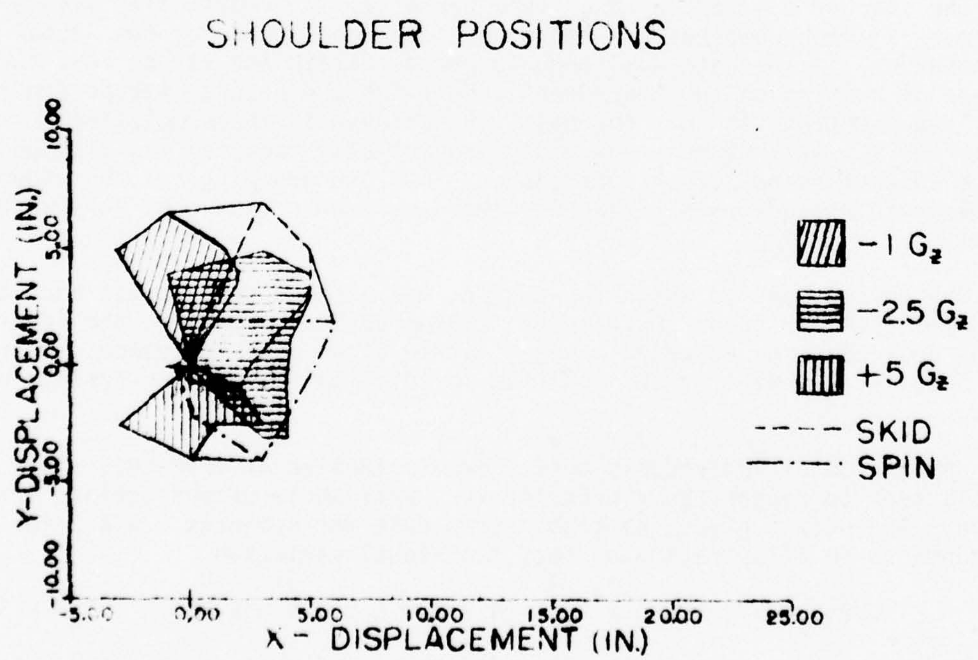


FIGURE 5 - Environmental Envelopes (Tight Straps).

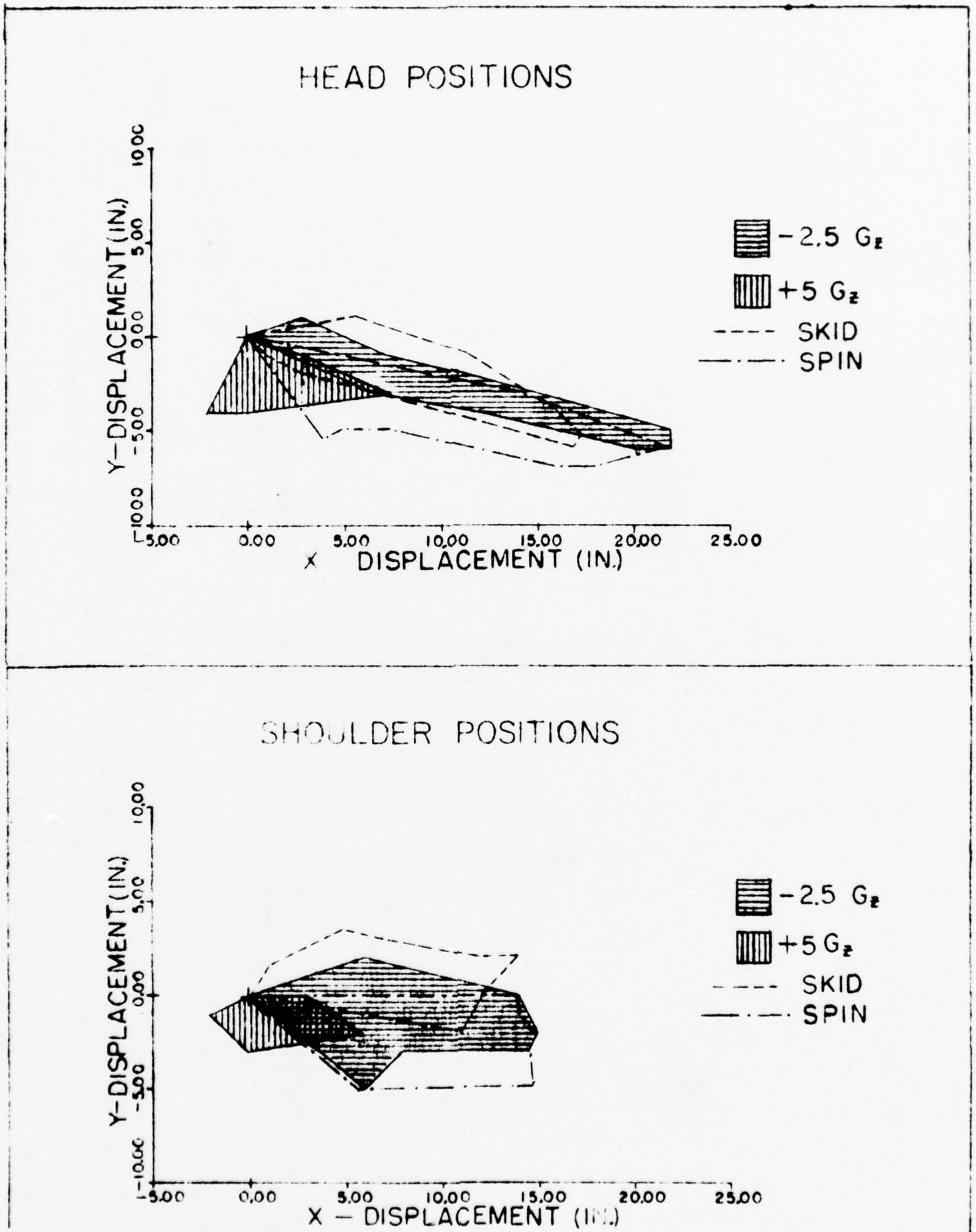


FIGURE 6 - Environmental Envelopes (Loose Straps).

FIGURE 7 - $-2.5G_x$ Environments for Head and Shoulder Motion; Tight versus Loose Harness Straps.

Although tight straps restrict reach, they do not prevent involuntary slumping and other motions by various segments of the body when severe forces are applied. Loose straps, while generally enabling greater reach, aggravate the force induced motions. Subjects who have an infinite combination of different individual percentiles and body proportions respond in varying patterns to both tight and loose straps.

Subjects tend to give experience-oriented evaluations of proposed improvements due to their own physical measurements which may or may not be generally applicable.

The environments which caused the greatest difficulty were those that contained the negative (2.5) G_x component or the negative G_z component. Both of these acceleration components are often encountered in emergency environments where rapid egress is imperative to the health of the individual.

The strong $-G_x$ force is particularly detrimental with loose straps since it can carry the subject out of position for the essential reach motion, out of body position for safe ejection, and out of position for continued control of the aircraft.

It has become an acceptable "fact" that the forces will be less detrimental if the harness strap is tight; however, this mode has been shown to prevent certain necessary actions from being accomplished by subjects within certain percentile ranges and body proportions. It should be remembered that individuals in a given weight range may be short, stocky, tall or slim.

Comparison of the data herein with those previously reported indicates that the effect of the adverse environment upon the individual and upon his response thereto are strongly dependent on the overall design of the specific seat-harness complex. Therefore, it is recommended that seats now in design/production be examined with the restraint system contemplated for use under dynamic emergency conditions. This would ensure that "improvements" to seat-harness-restraint system do not impose unwarranted limits on the subject reach and capability to respond properly and safely. It is the total complex rather than the individual components which should be tested. Implied under reachability is the location and activation of the control device.

Due to the wide variation that occurs across individuals, even when they meet requirements for acceptability as naval crewmen, it is suggested that a physical/anthropological measurement safety instruction be developed for each individual who may some day have to resort to ejection. By comparison of the individual's own unique dimensions to standard computerized criteria, the individual can be made aware of his own peculiarities and the limitations that result such as the short sitting height and short functional reach combination identified herein. Other combinations with detrimental results will probably surface. Then should he be so unfortunate as to be involved in an aircraft emergency, such knowledge may save him from wasting precious seconds, possibly enable him to save the aircraft, reduce the probability of serious ejection injury, or even save his life.

Existing equipment needs modification to provide the lower ejection handle with the same smooth uniform pull in the detent-to-fire phase that is found in the actuation of the face curtain. It is this smooth quick response that contributed to the face curtain's reputation as the primary ejection handle.

In interpreting and using the data presented in this report, it should be remembered that these data were generated by subjecting humans to unusual environments. Thus, the data range was limited by concern for the well being of these individuals. During flight, the environment may be far more severe. For example, one of the environments explored herein is $-2.5\ G_x$, while environments as great as $-7\ G_x$ are being reported. Obviously the difficulties encountered in the latter environment could be much greater. Thus, the effects registered in this report are representative of emergencies most often encountered rather than those of the extremes.

The position envelopes resulting from dynamic forces which are reported are preliminary in nature. Envelopes of this type can have many uses. They can assist in planning equipment locations within the cockpit. These envelopes which detail possible pilot positions under adverse environments are areas which should remain free of encumbrance. Today's pilots are further burdened by life preservers,survival vests with bulky items, items which were not worn in the experiments reported here. These items can also contribute to the lessening of movement freedom by the pilot.

Knowledge of likely positions of aircrewmen in adverse aircraft attitudes will assist in the determination of ways to avoid severe cockpit impact and ejection injuries. Designers of clothing, helmets, protective wear, restraint system, etc. should find these data useful.

R E F E R E N C E S

1. Emergency Airborne Escape Summaries, 1970 through 1975, Naval Safety Center.

2. Fessenden, E.; Influence of Various Acceleration Environments on the Ability to Activate Controls for Energy Devices. Report No. NADC-75079-40. 17 July 1975.

3. Sepecification No. MIL-S-18471E(AS) of 1 May 1974.

4. Gifford, E.C.; Anthropometry of Naval Aviators - 1964. Naval Air Engineering Center, Philadelphia, Pa., Report No. NAEC-ACEL-533, 8 Oct 1965.

APPENDIX A

COMMENTS ON THE INDIVIDUAL VARIATIONS OF SUBJECTS ASSUMING THE ORIGINAL VIDEO POSITION

Subject #1 had considerable freedom of movement within the torso straps even though they were pulled as tight as possible. This freedom caused his initial position to vary 3 inches prior to the onset of adverse environment. This circumstance results in a greater variation in the degree of reproducibility of his individual efforts. Subject #6 exhibited the same type of variation but to a lesser degree.

The remainder of the subjects achieved a remarkable degree of consistency in returning to their original positions. Subject #5 moved his shoulders in anticipation of the device he was to activate. This was not considered as detrimental to the experiment since a pilot might well react in this manner when he had made the decision as to the device he would be reaching for.

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APPENDIX B

GRAPHS OF POSITIONS (TORSO HARNESS STRAPS TIGHT) GROUPED ACCORDING TO:

	Chart No.
All Variables	B-1
First Repetition	B-2
Second Repetition	B-3
Subject No.	
1	B-4
2	B-5
3	B-6
4	B-7
5	B-8
6	B-9
7	B-10
8	B-11
10	B-12
Environment - +5Gz	B-13
Environment - -1Gz	B-14
Environment - -2.5Gz	B-15
Environment - Skid	B-16
Environment - Spin	B-17
Device - Drag	B-18
Device - Stores Release	B-19
Device - Lower Ejection Handle	B-20
Device - Face Curtain	B-21

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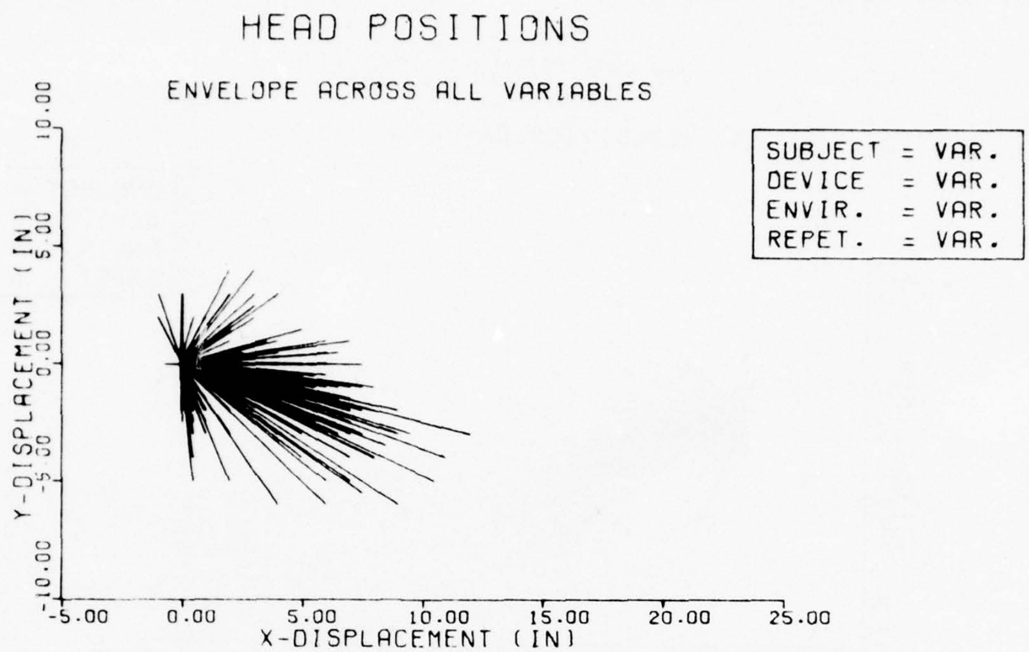
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ENVIR. = VAR.
REPET. = VAR.
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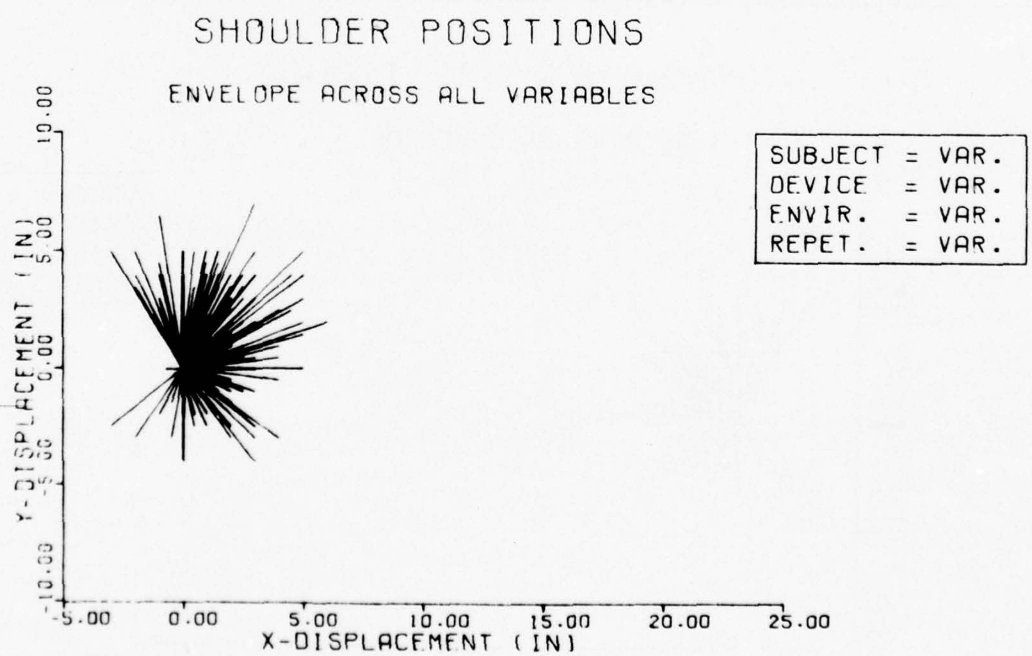
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)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ENVIR. = VAR.
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5.00
0.00
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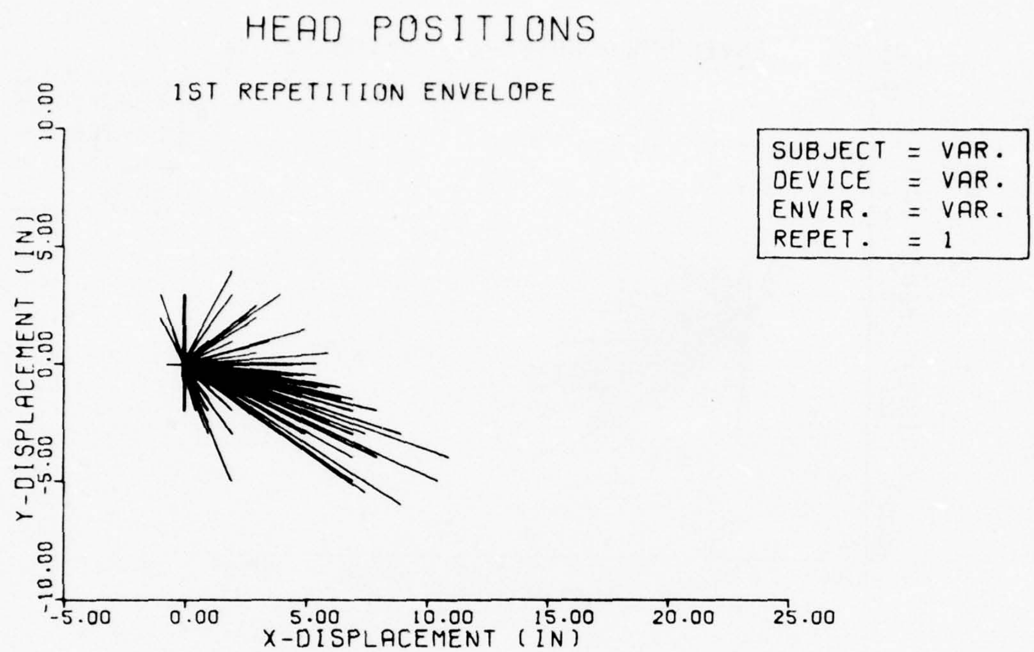
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-1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ENVIR. = VAR.
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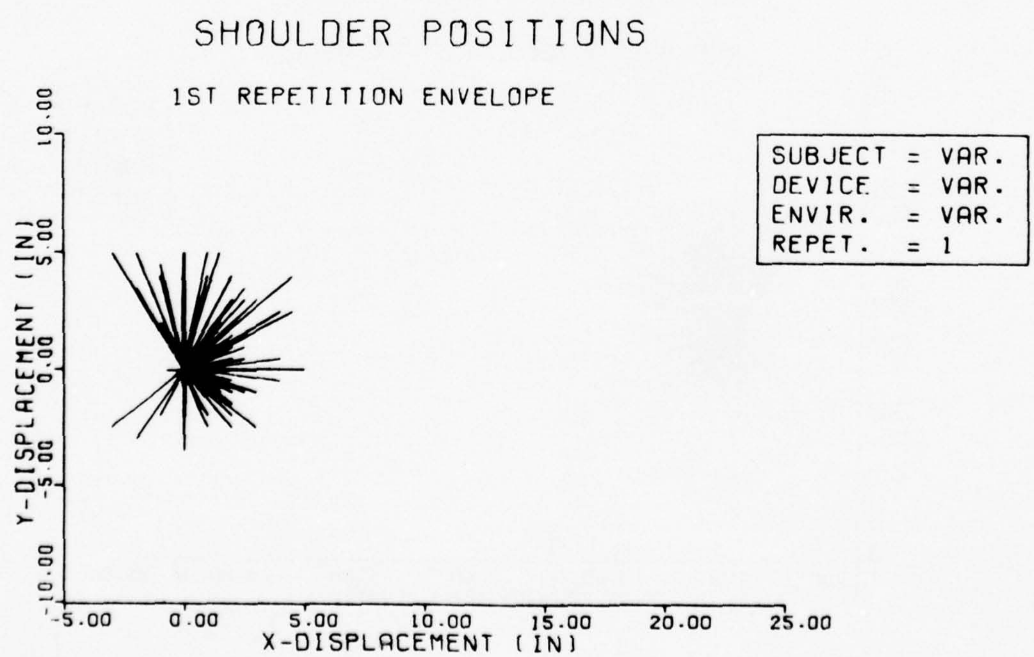
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)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DEVICE = VAR.
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0.00
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10.00
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25.00
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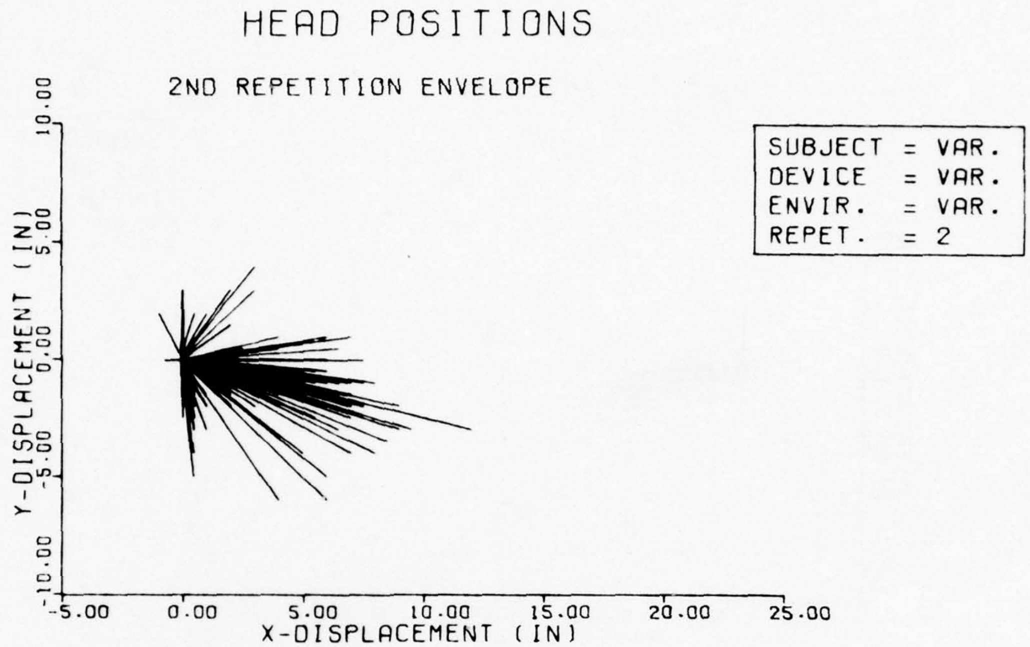
CHART B-2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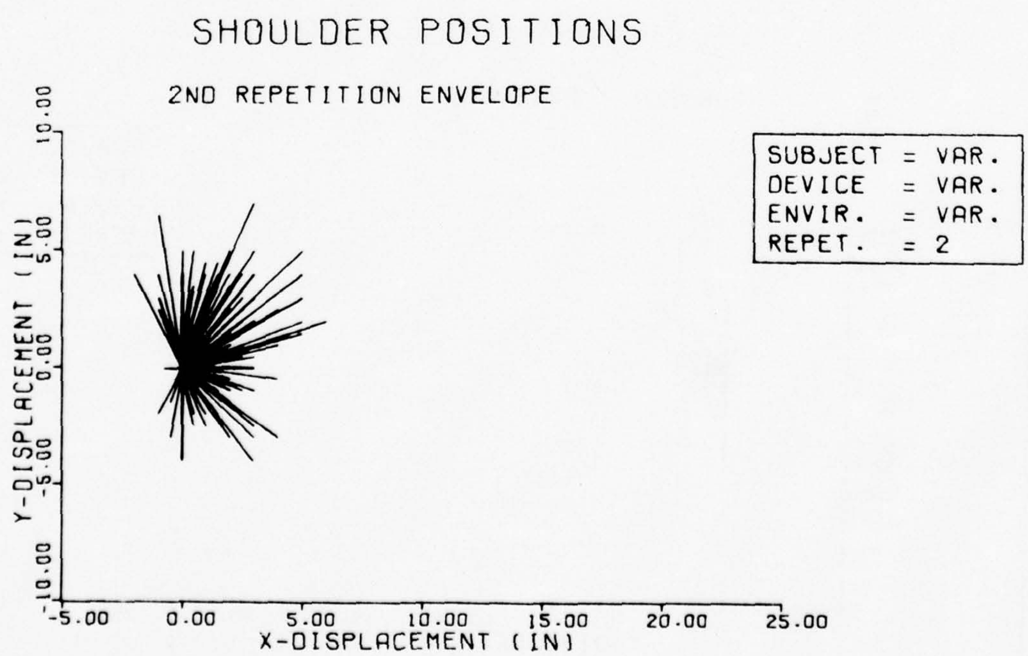
20.00
25.00
X-DISPLACEMENT (IN)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0.00
5.00
10.00
15.00
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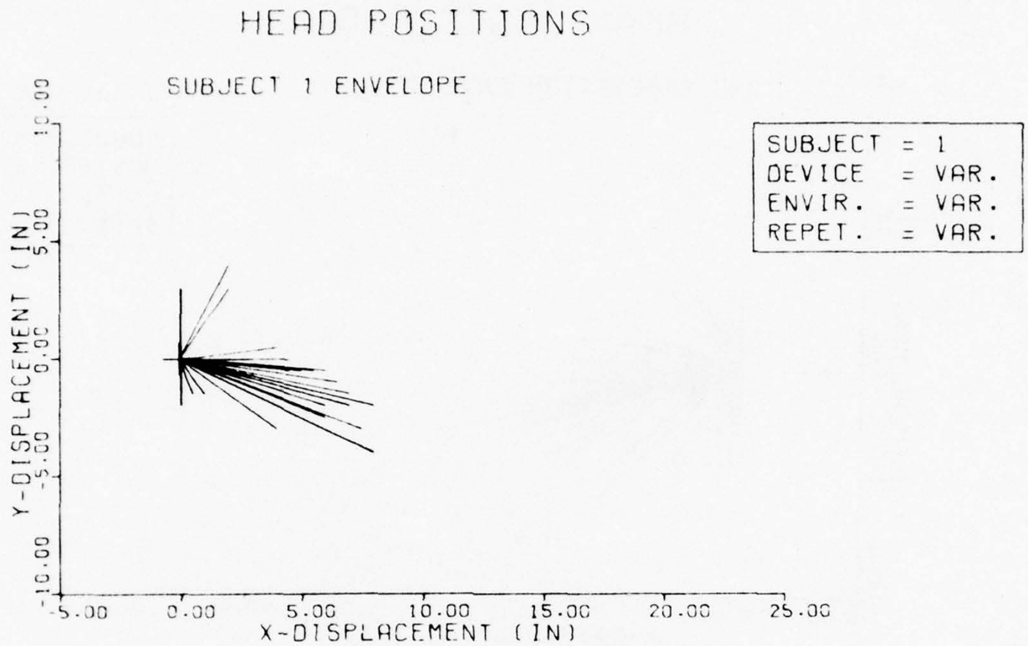
25.00
X-DISPLACEMENT (IN)

CHART B-3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REPET. = VAR.
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0.00
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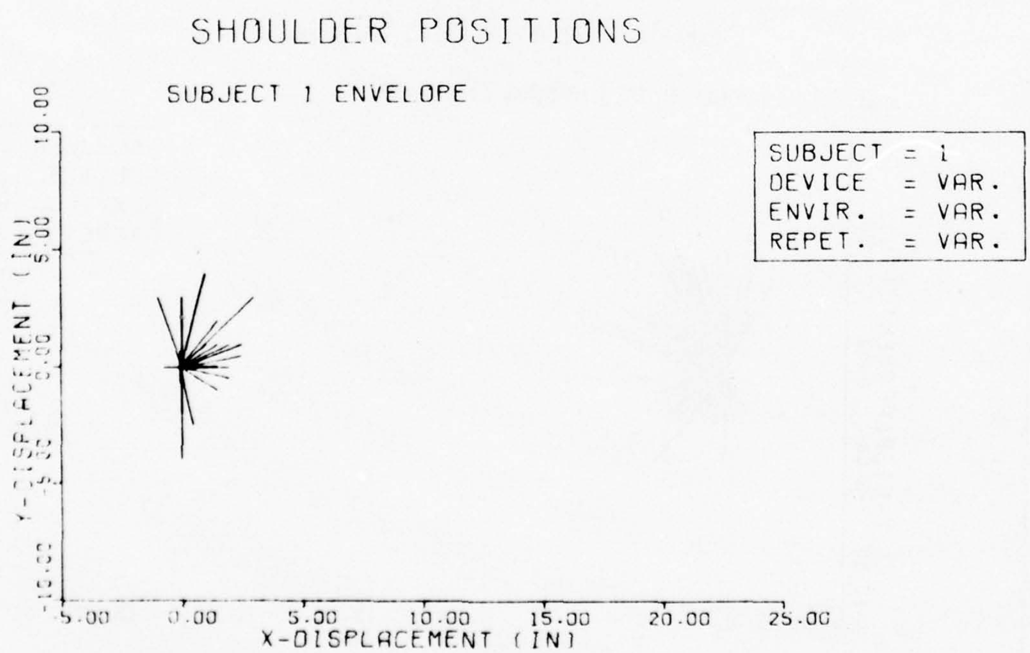
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)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REPET. = VAR.
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10.00
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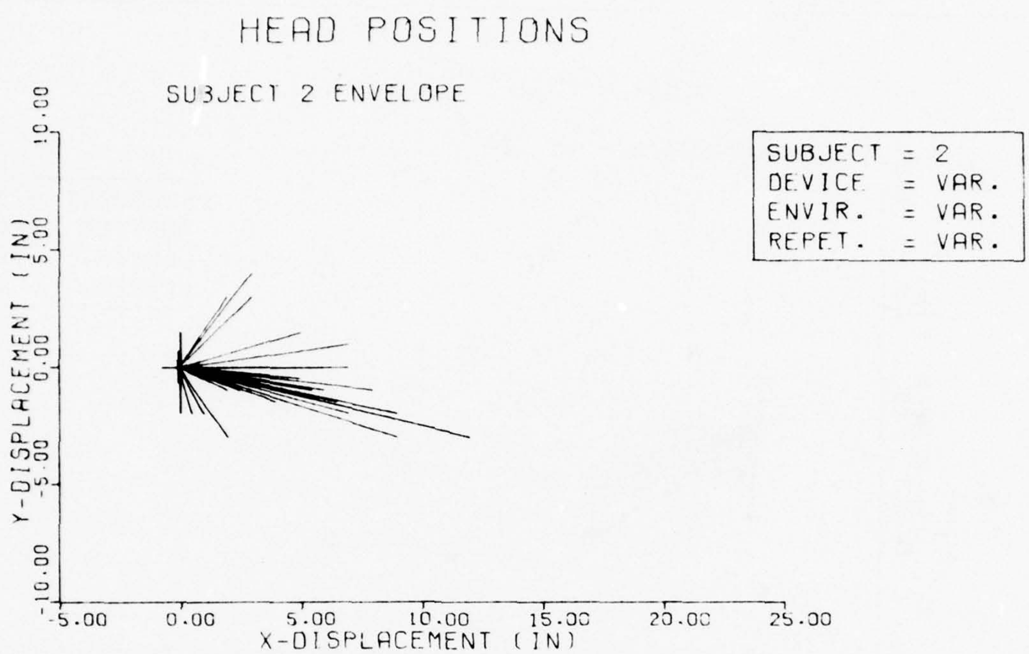
25.00
X-DISPLACEMENT (IN)

CHART B-4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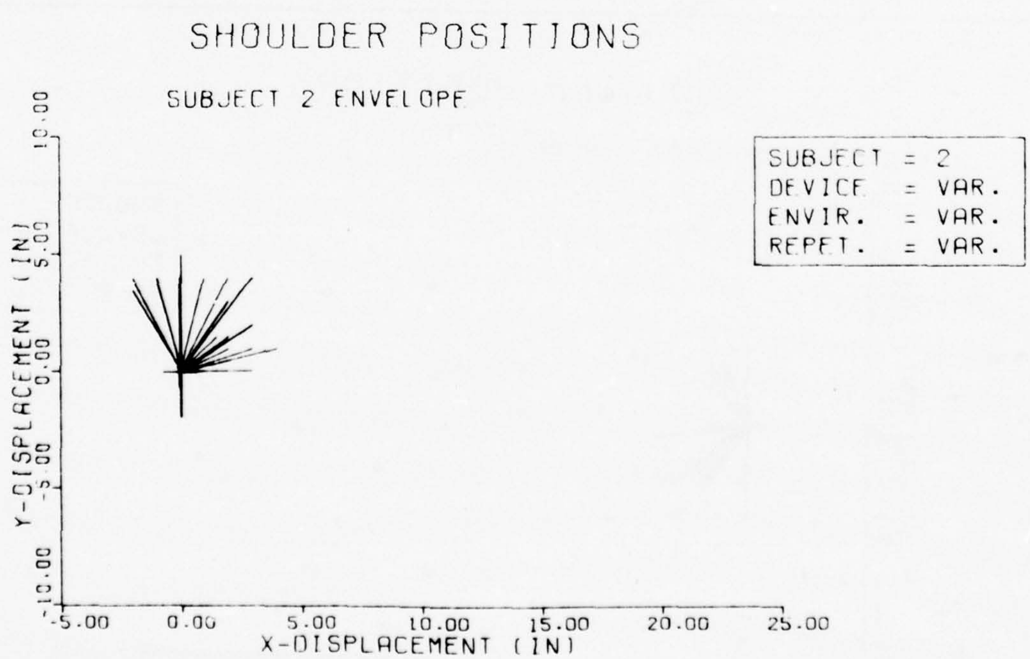
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)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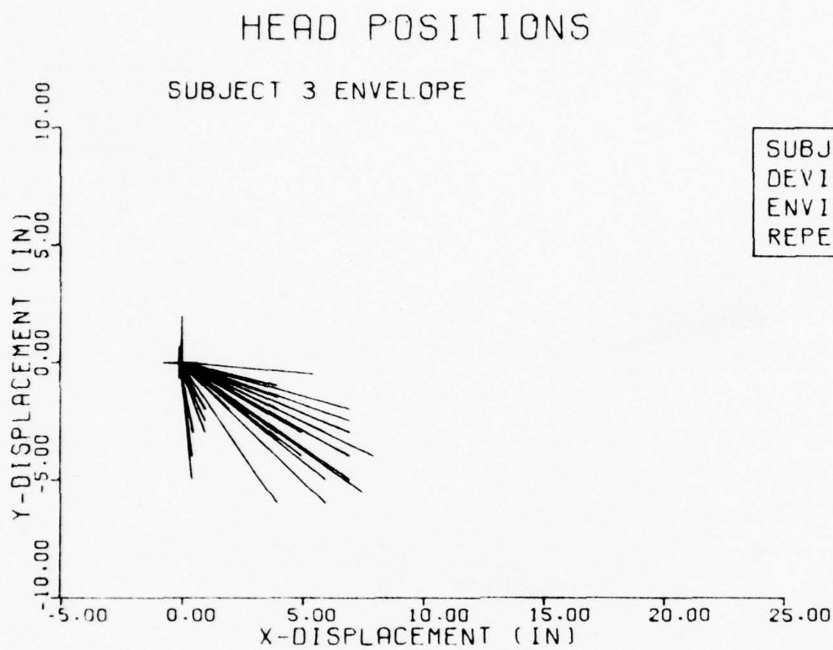
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-5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0.00
5.00
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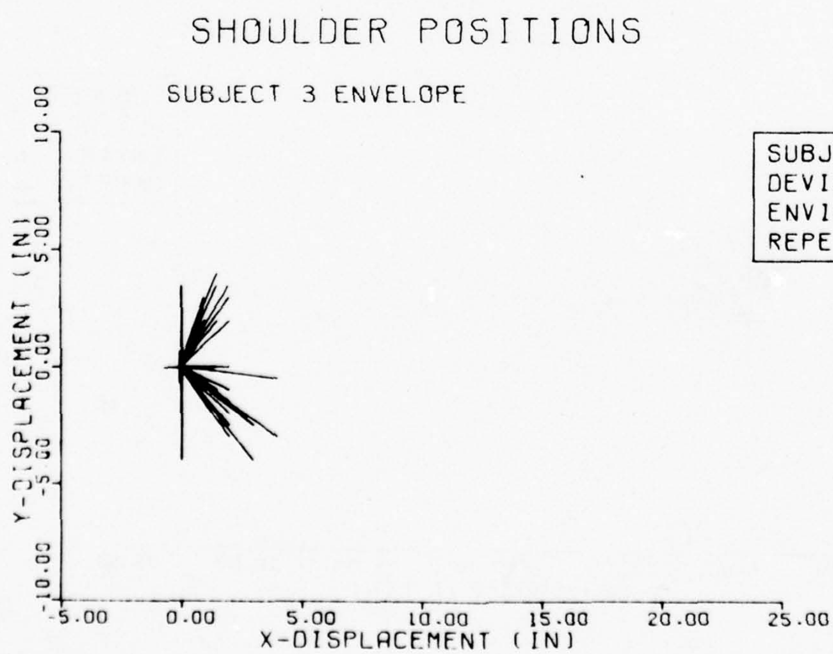
15.00
20.00
25.00
X-DISPLACEMENT (IN)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REPET. = VAR.
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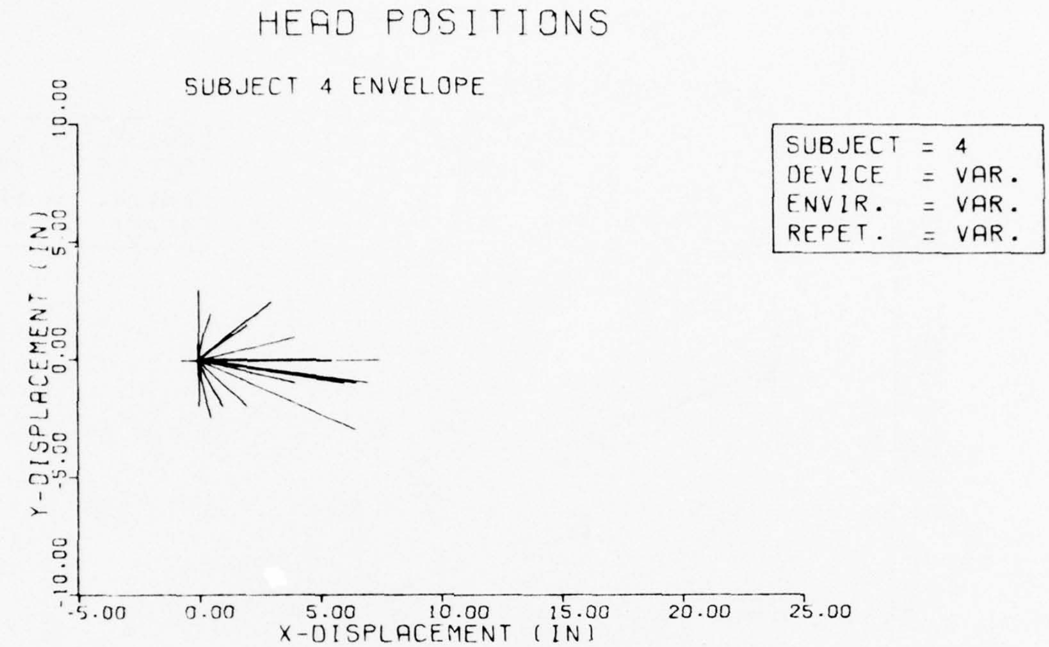
X-DISPLACEMENT (IN)

CHART B-6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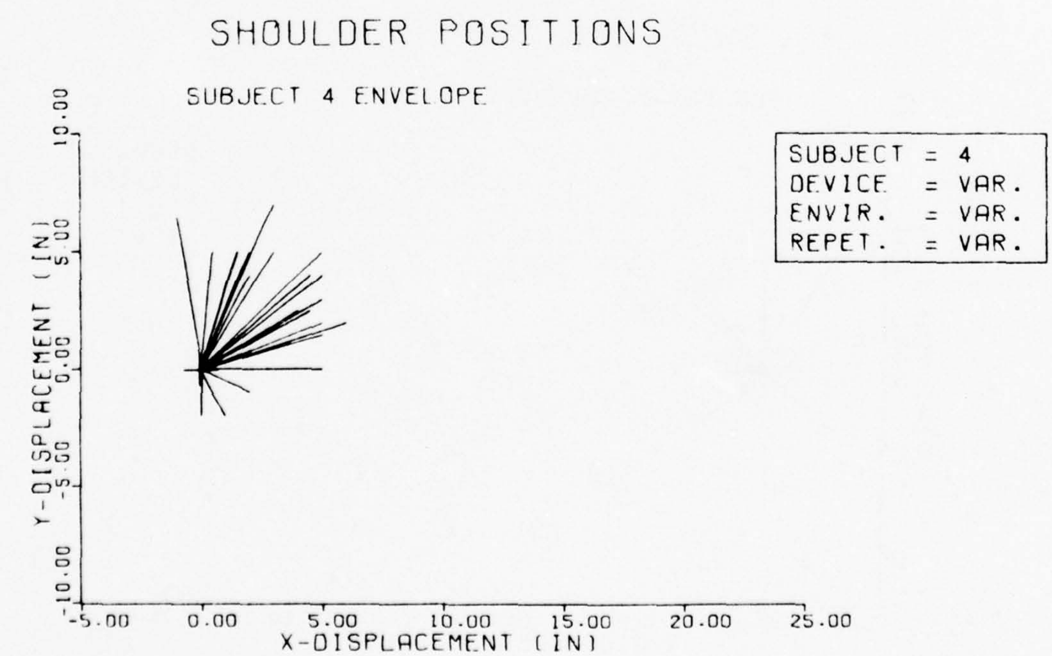
X-DISPLACEMENT (IN)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5.00
10.00
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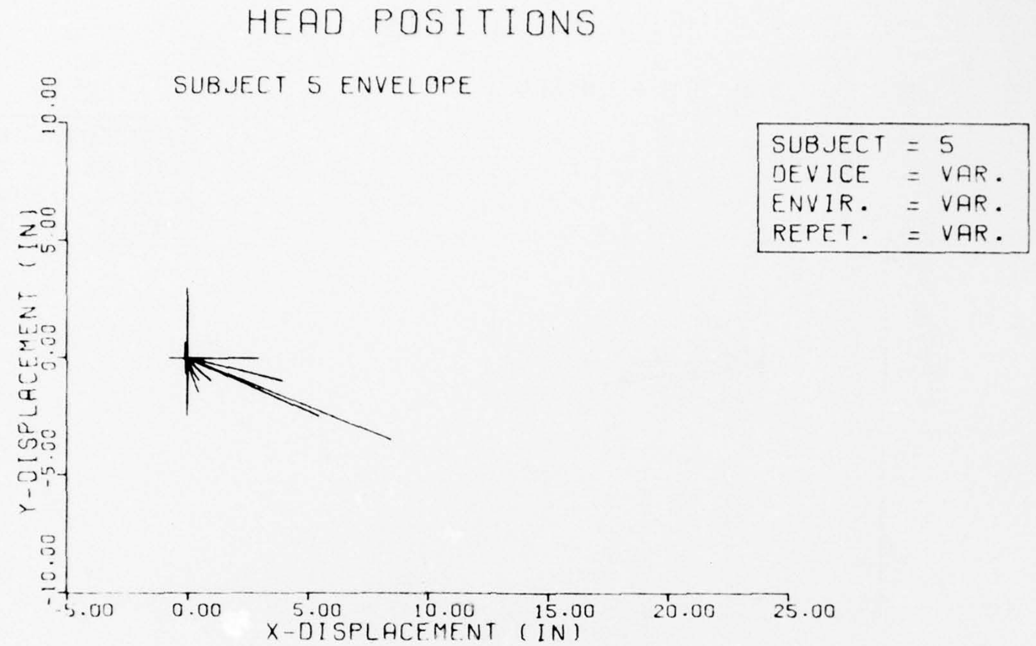
25.00
X-DISPLACEMENT (IN)

CHART B-7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10.00
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20.00
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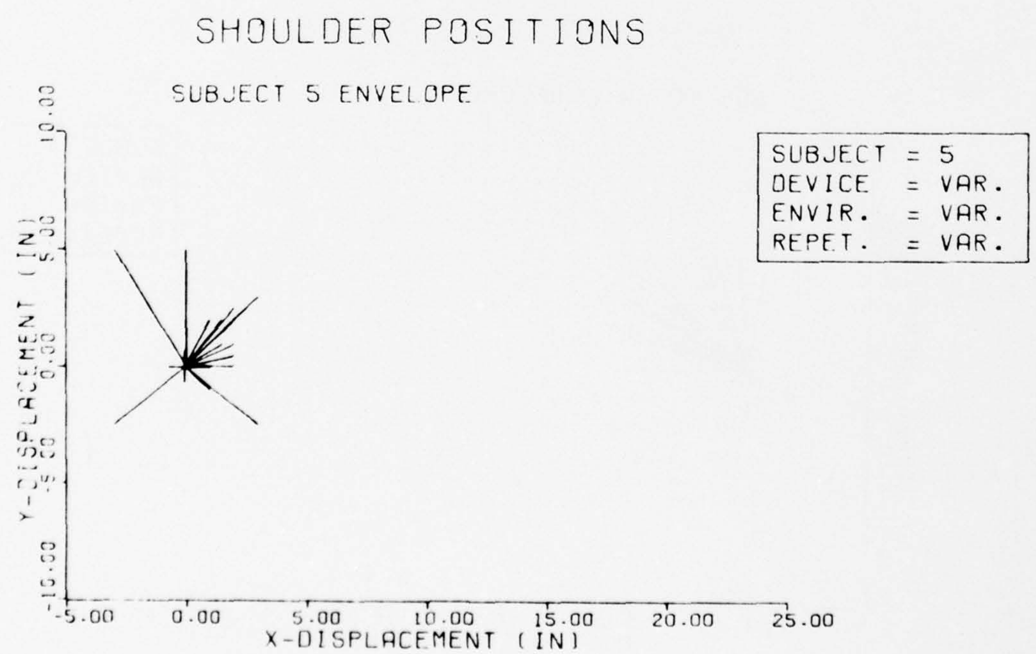
X-DISPLACEMENT (IN)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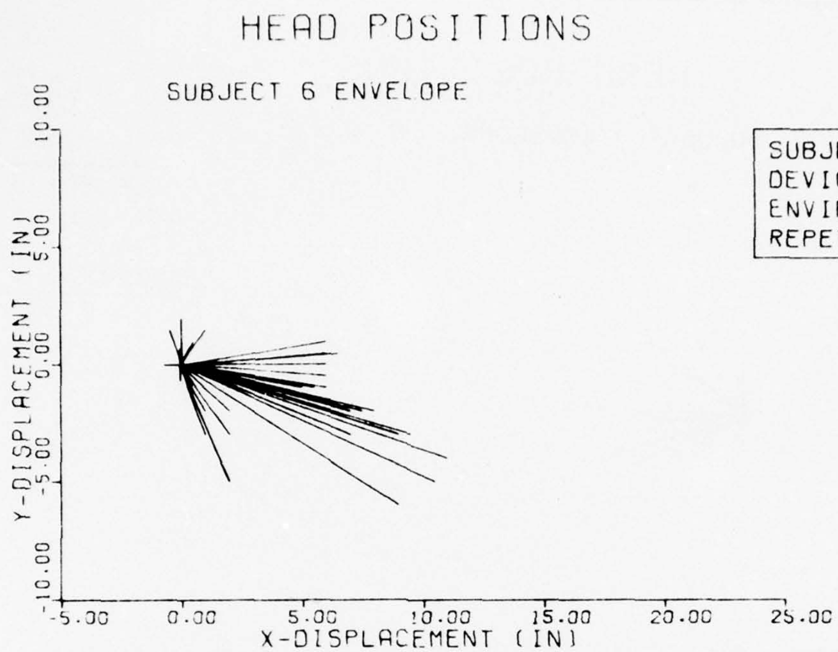
25.00
X-DISPLACEMENT (IN)

CHART B-8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X-DISPLACEMENT (IN)
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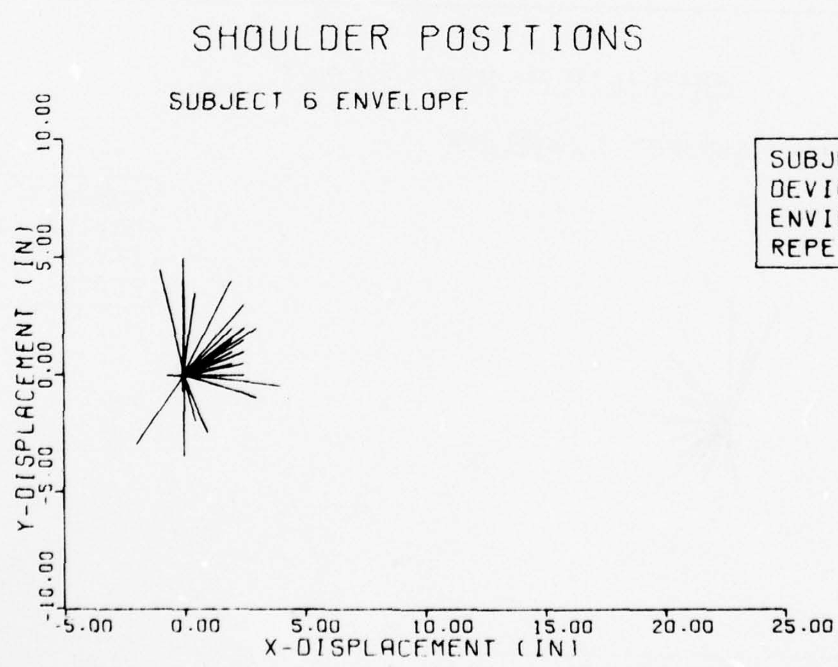
5.00
10.00
15.00
20.00
25.00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X-DISPLACEMENT (IN)
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0.00
5.00
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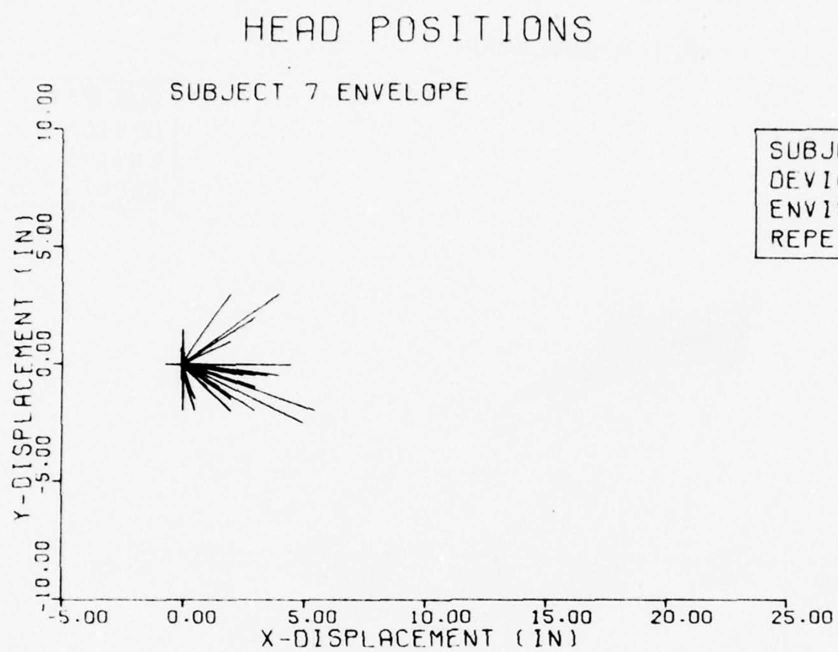
20.00
25.00

CHART B-9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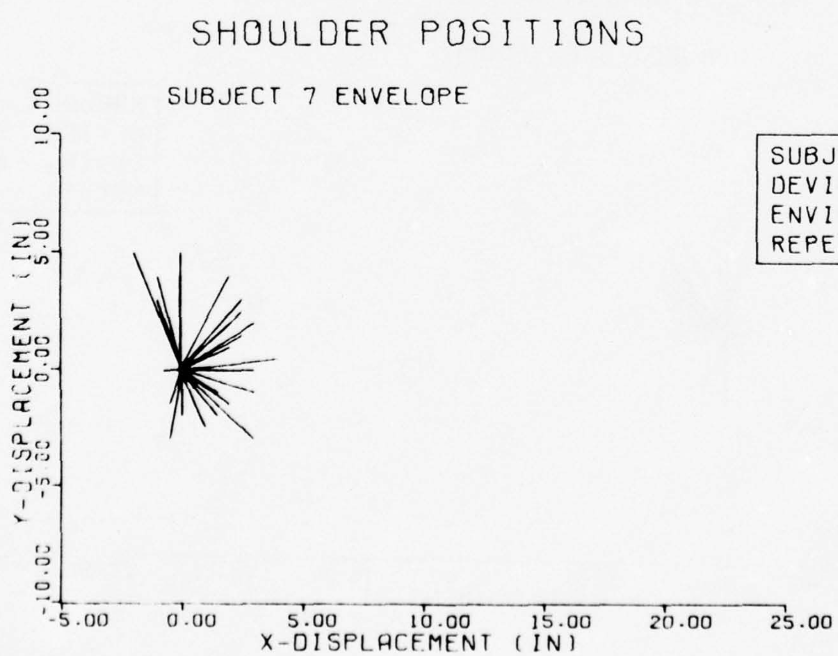
25.00
X-DISPLACEMENT (IN)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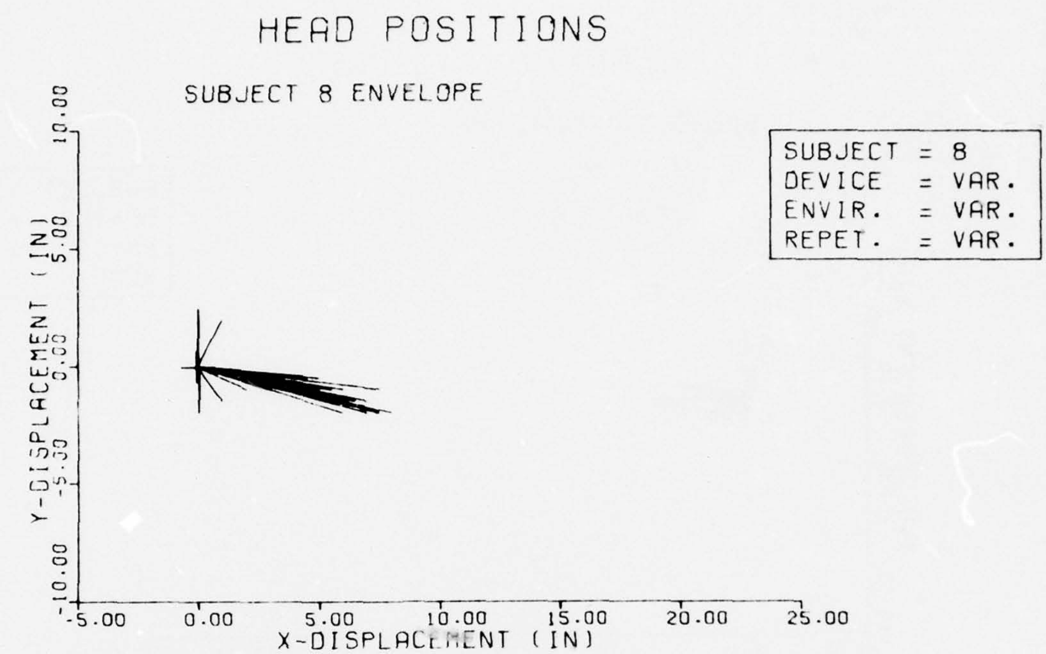
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-10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0.00
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0.00
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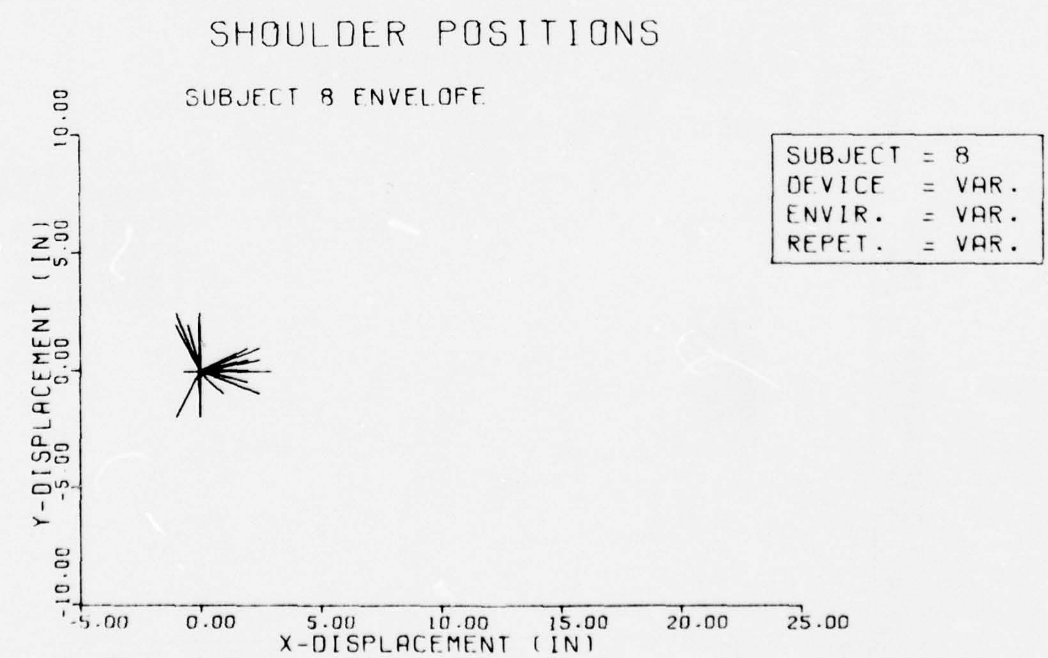
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)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ENVIR. = VAR.
REPET. = VAR.
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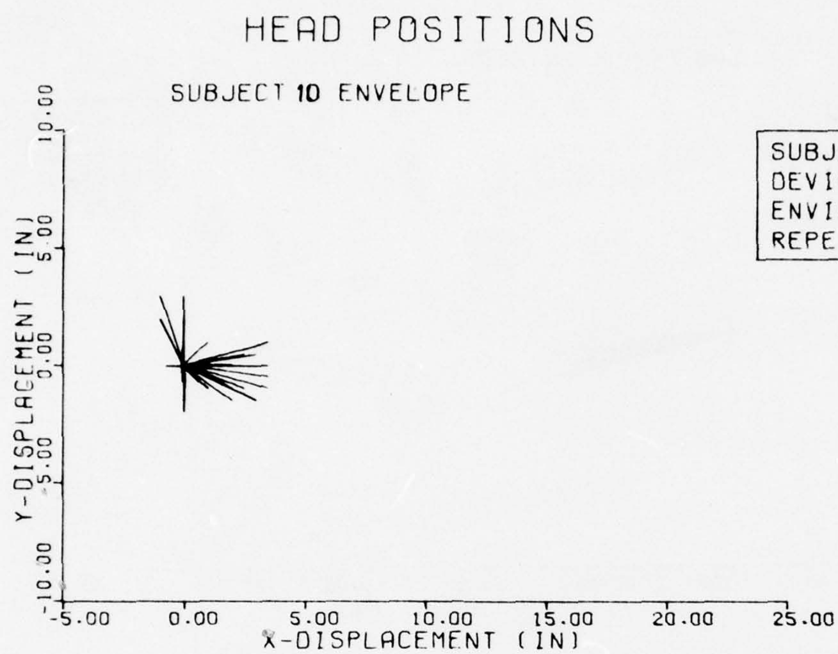
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-11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10.00
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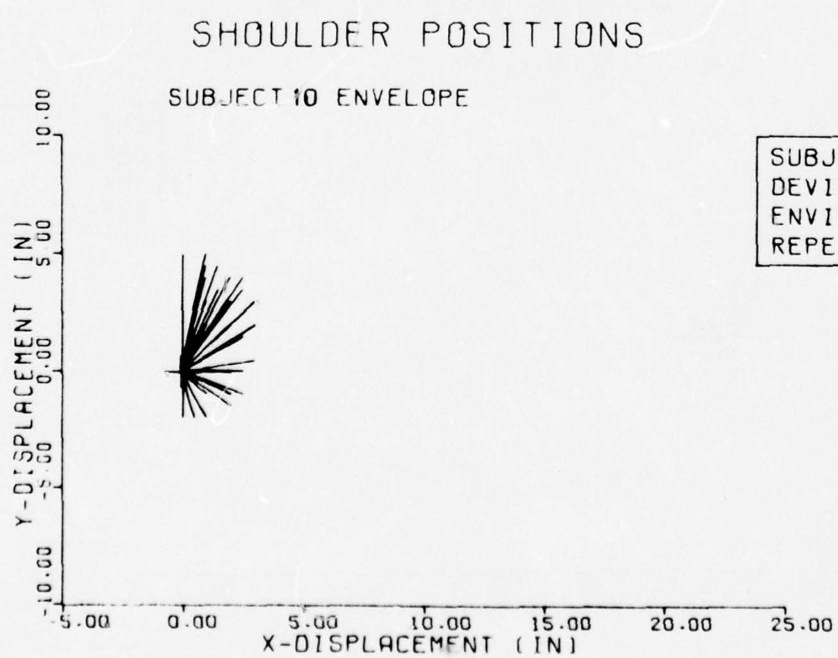
20.00
25.00
X-DISPLACEMENT (IN)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REPET. = VAR.
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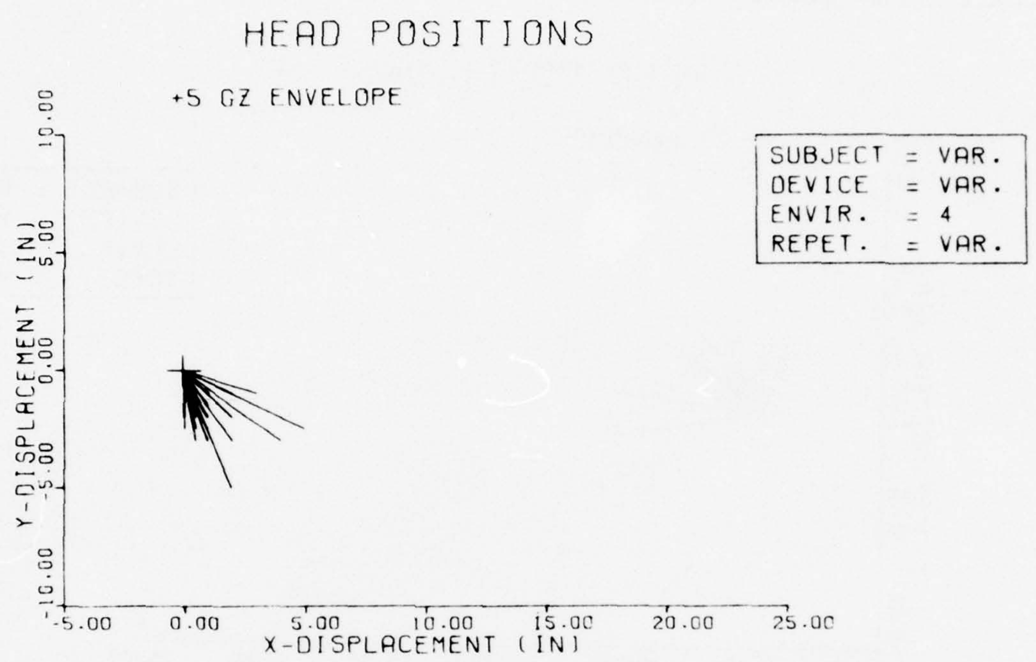
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-12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SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 4
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

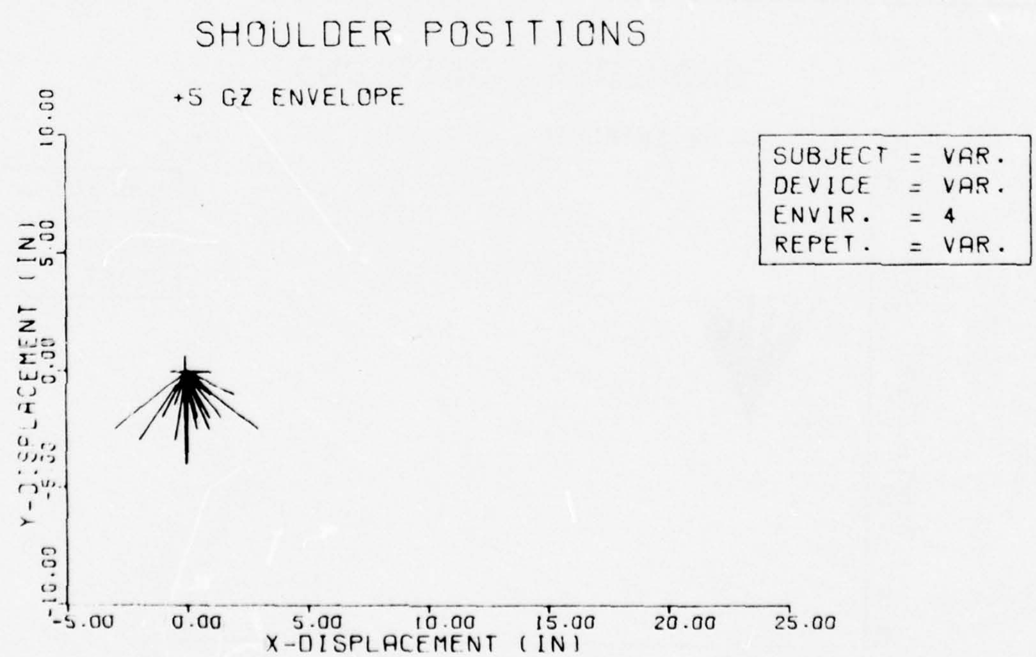
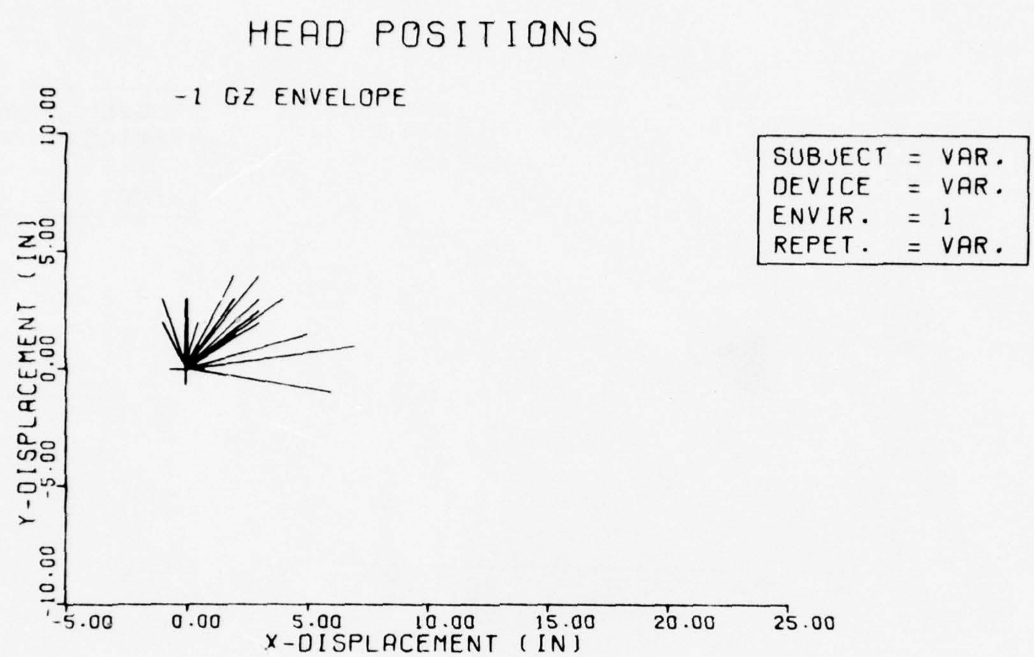

SHOULDER POSITIONS
+5 GZ ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 4
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-13


HEAD POSITIONS
-1 GZ ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 1
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

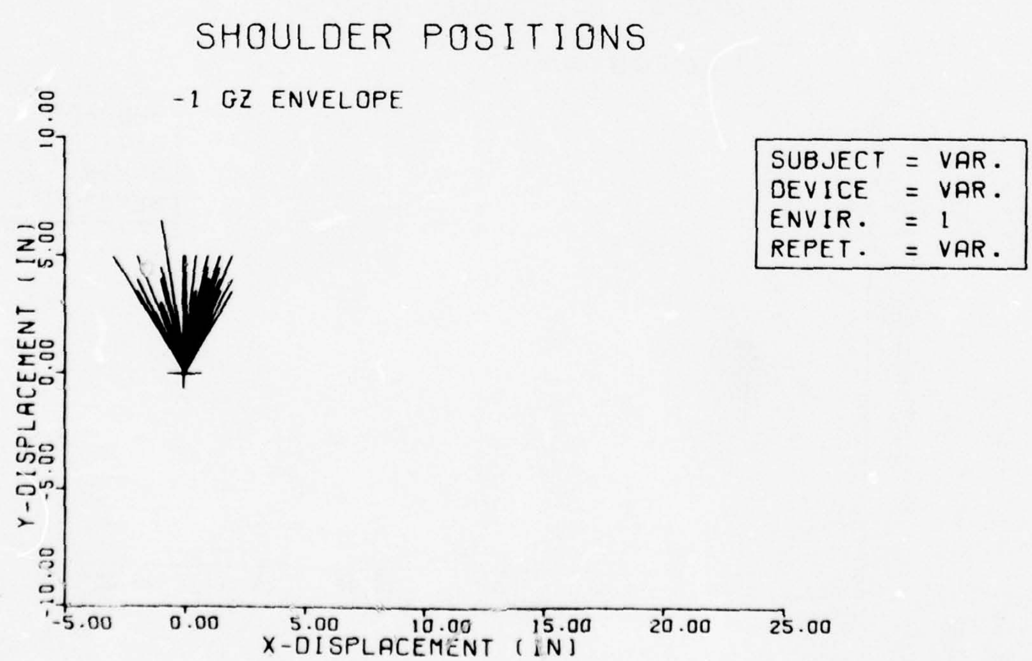
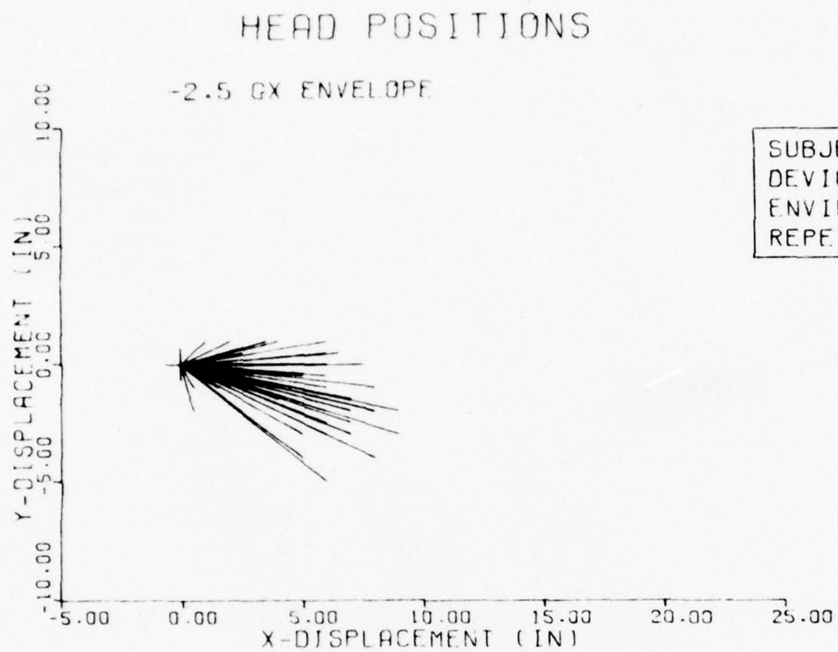

SHOULDER POSITIONS
-1 GZ ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 1
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-14


HEAD POSITIONS
-2.5 GX ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

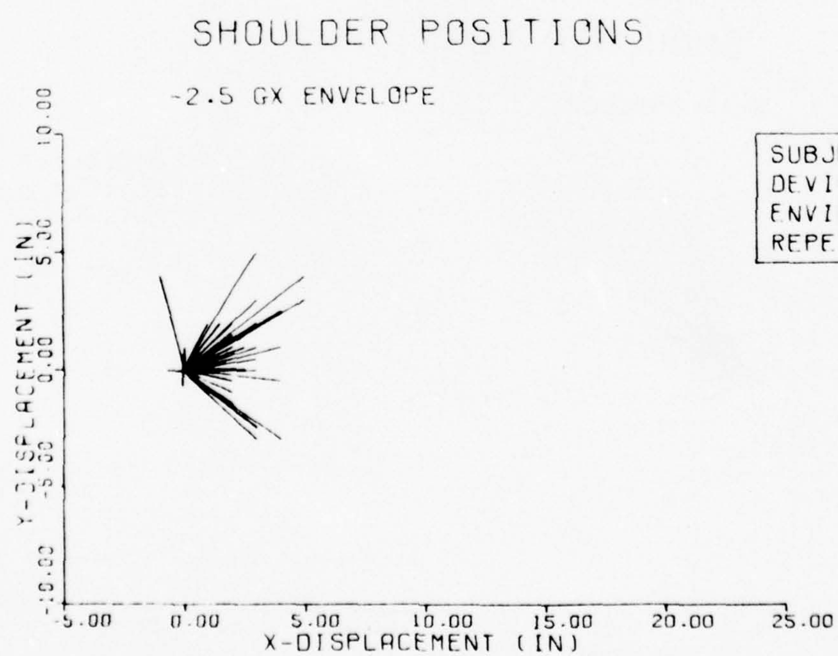
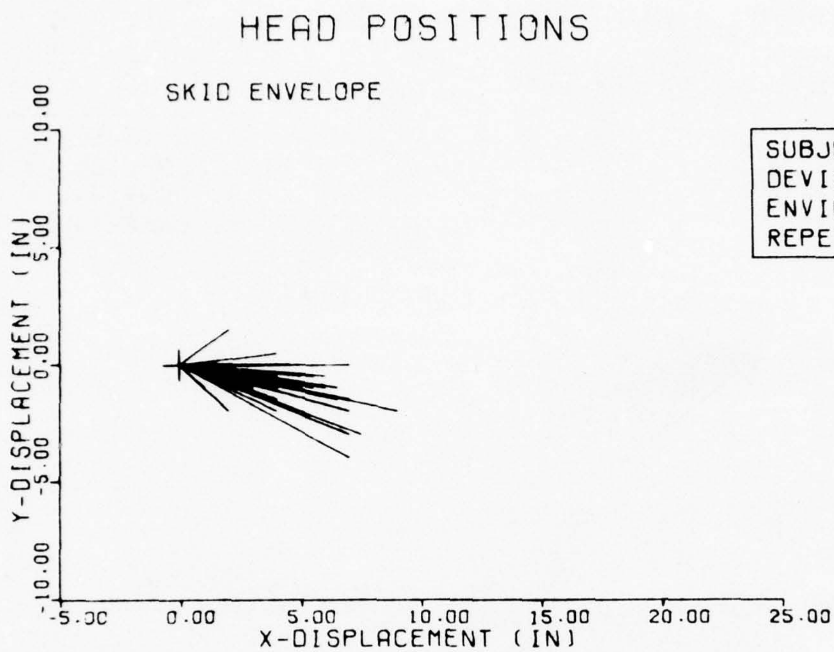

SHOULDER POSITIONS
-2.5 GX ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-15


HEAD POSITIONS
SKID ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 5
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

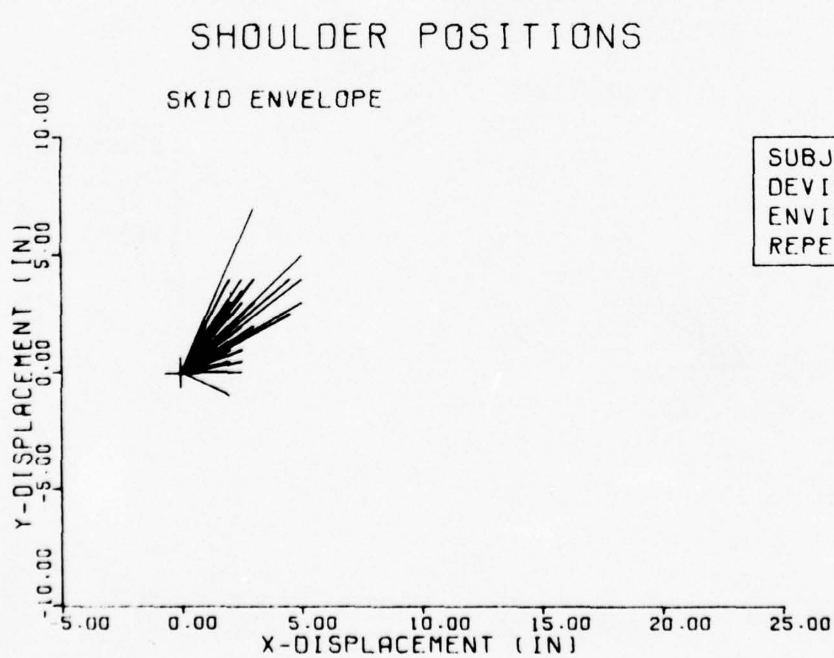
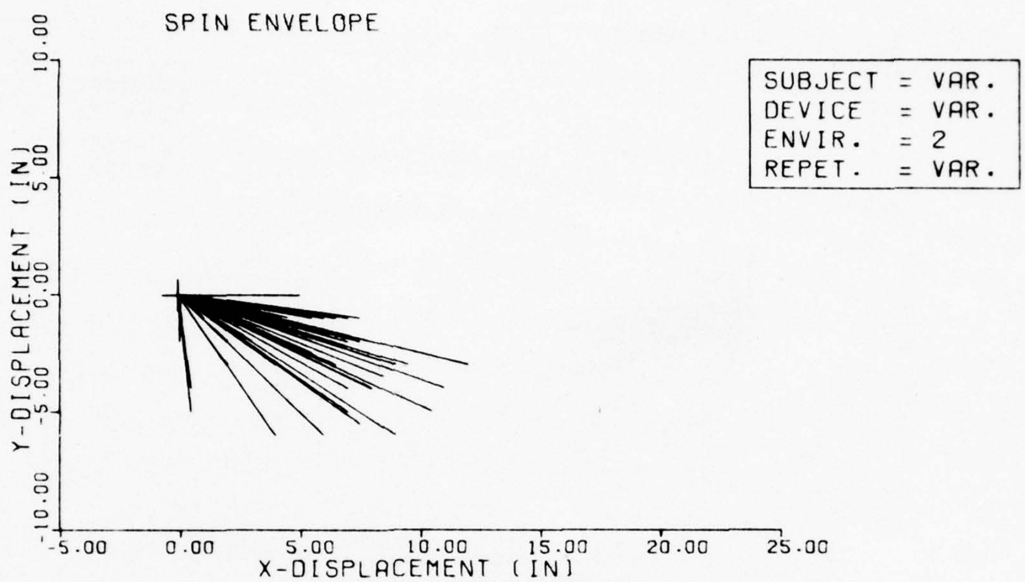

SHOULDER POSITIONS
SKID ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 5
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-16

HEAD POSITIONS



SHOULDER POSITIONS

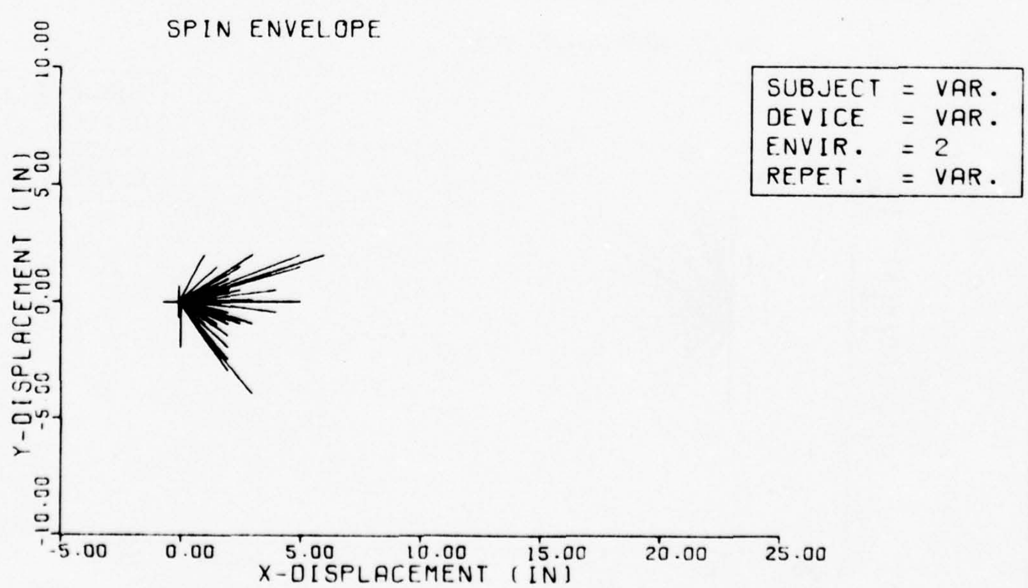
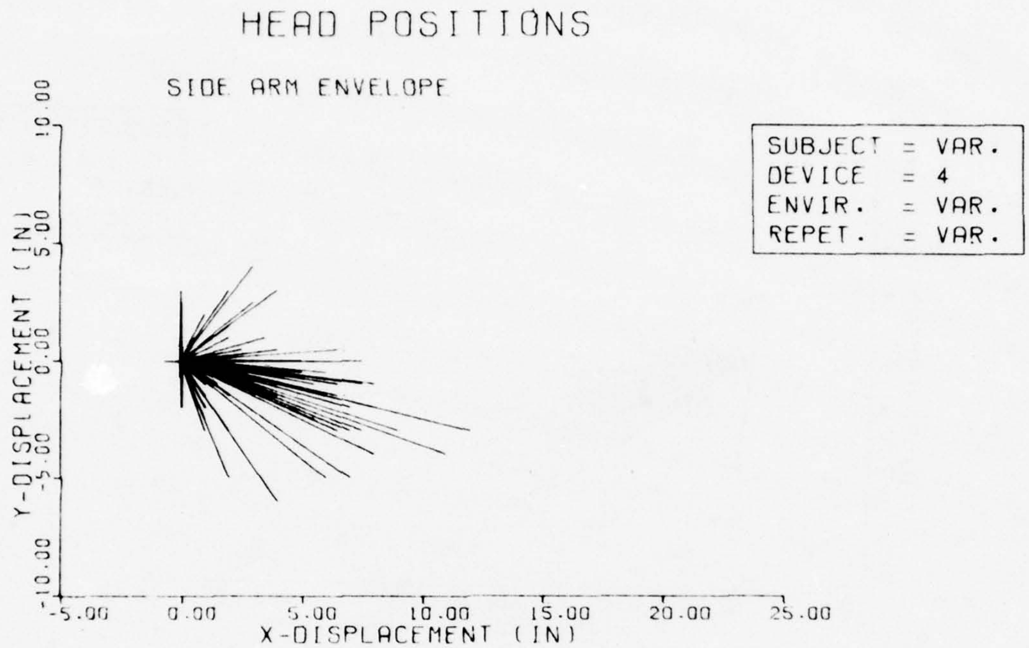
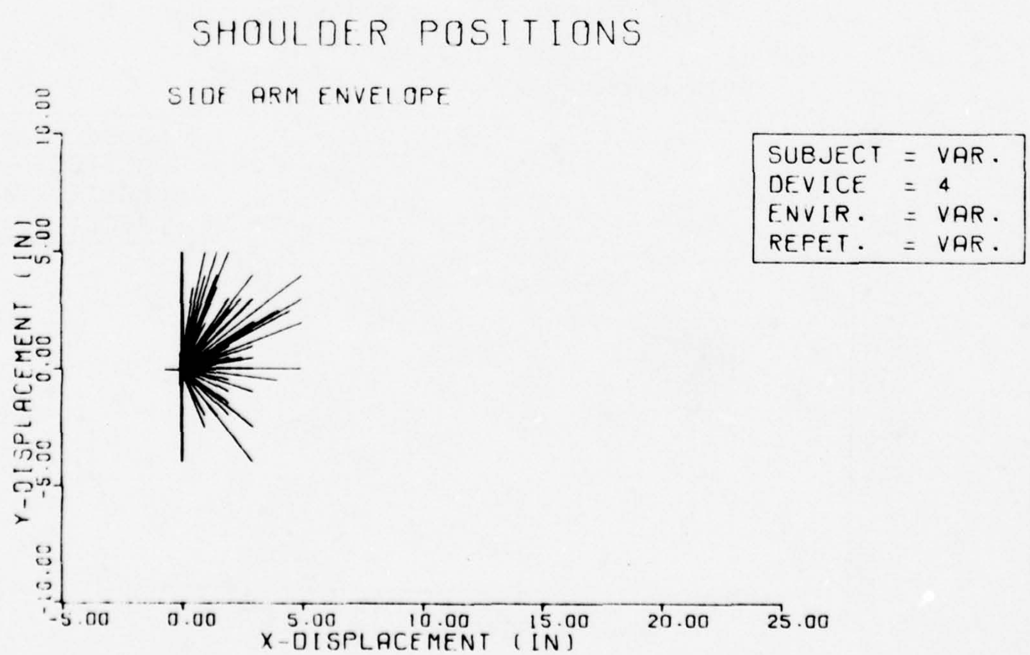


CHART B-17

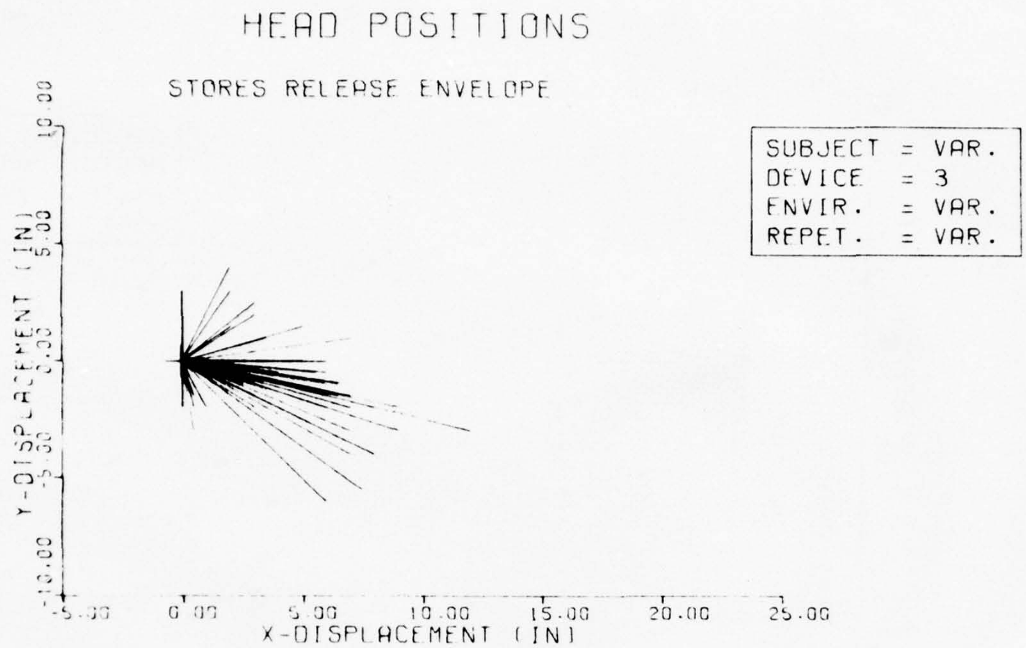


HEAD POSITIONS
SIDE ARM ENVELOPE
SUBJECT = VAR.
DEVICE = 4
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)



SHOULDER POSITIONS
SIDE ARM ENVELOPE
SUBJECT = VAR.
DEVICE = 4
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-18


HEAD POSITIONS
STORES RELEASE ENVELOPE
SUBJECT = VAR.
DEVICE = 3
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
-10.00
-5.00
0.00
5.00
10.00

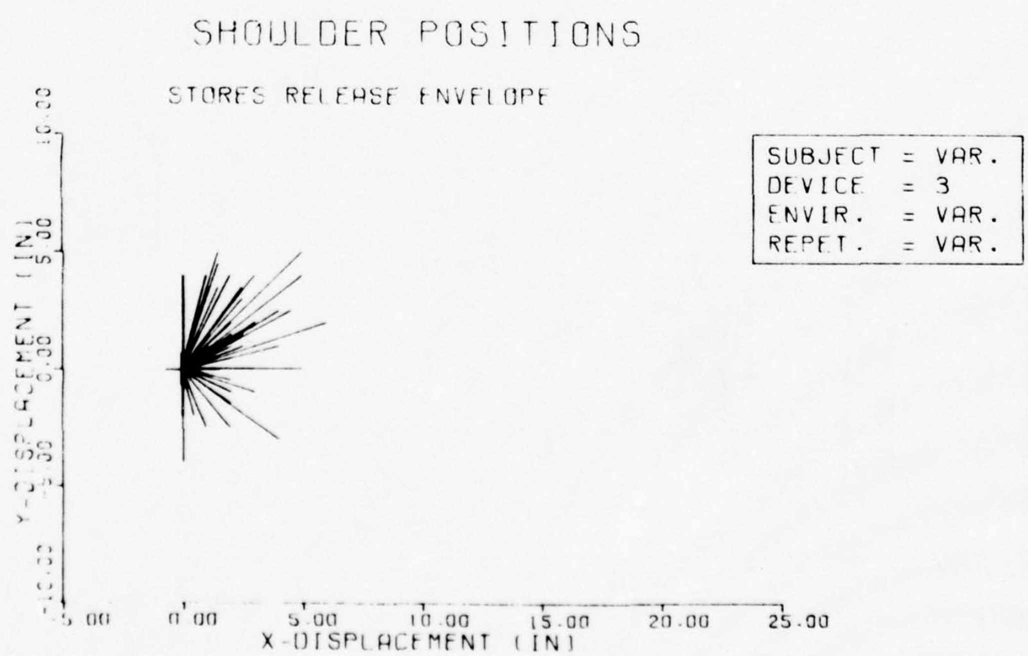
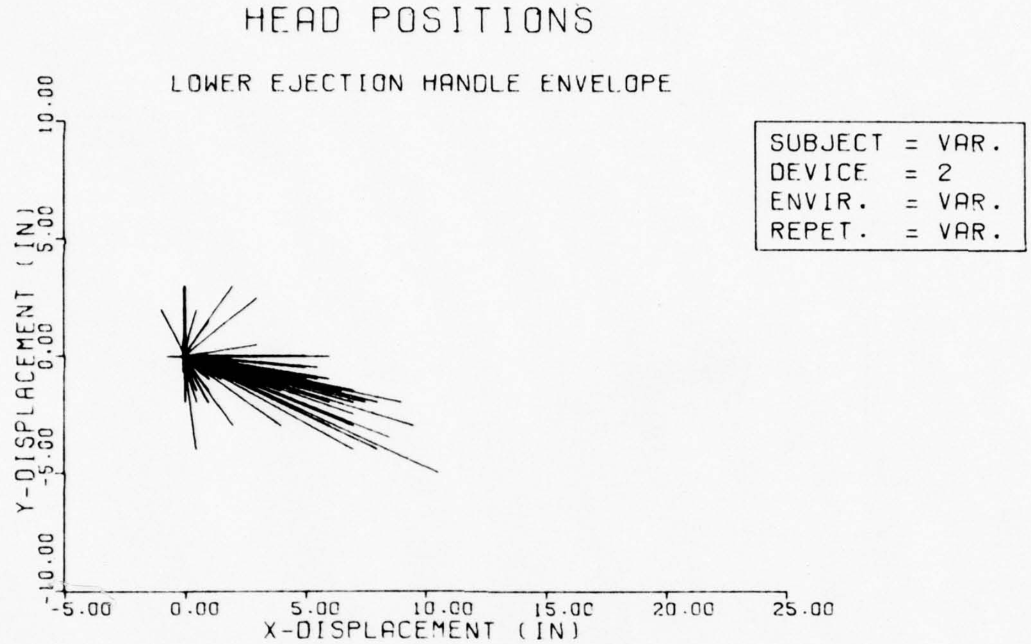

SHOULDER POSITIONS
STORES RELEASE ENVELOPE
SUBJECT = VAR.
DEVICE = 3
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
-10.00
-5.00
0.00
5.00
10.00

CHART B-19


HEAD POSITIONS
LOWER EJECTION HANDLE ENVELOPE
SUBJECT = VAR.
DEVICE = 2
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

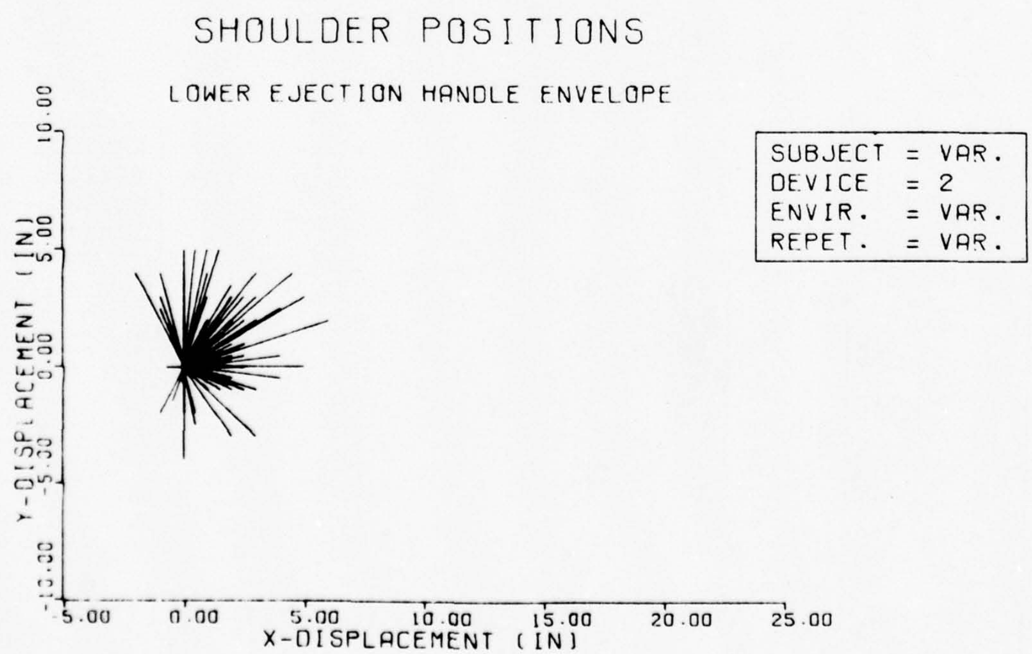
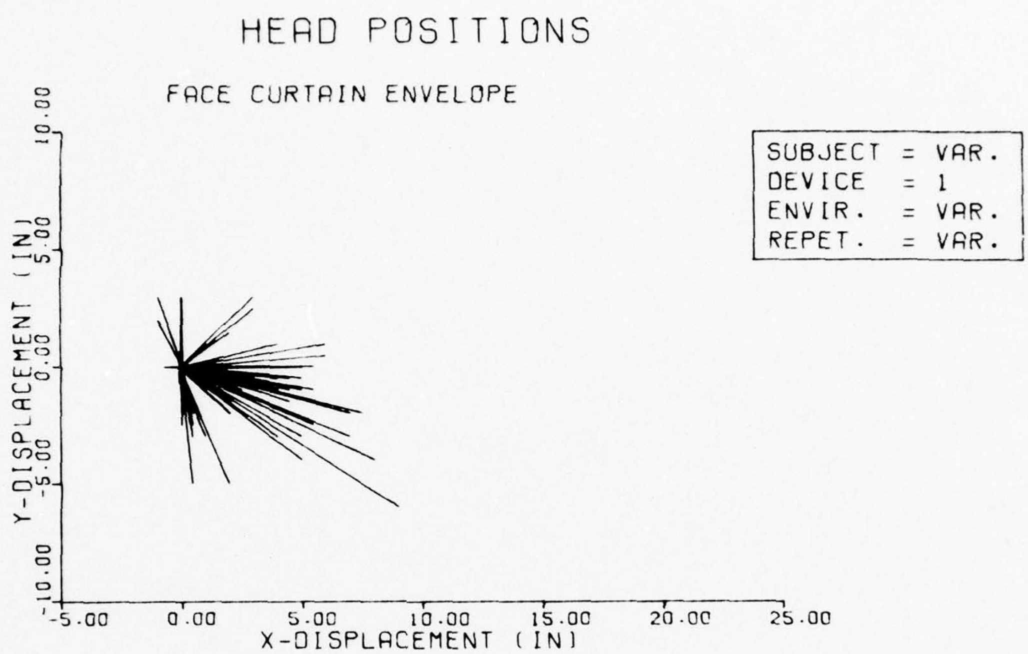

SHOULDER POSITIONS
LOWER EJECTION HANDLE ENVELOPE
SUBJECT = VAR.
DEVICE = 2
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-20


HEAD POSITIONS
FACE CURTAIN ENVELOPE
SUBJECT = VAR.
DEVICE = 1
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

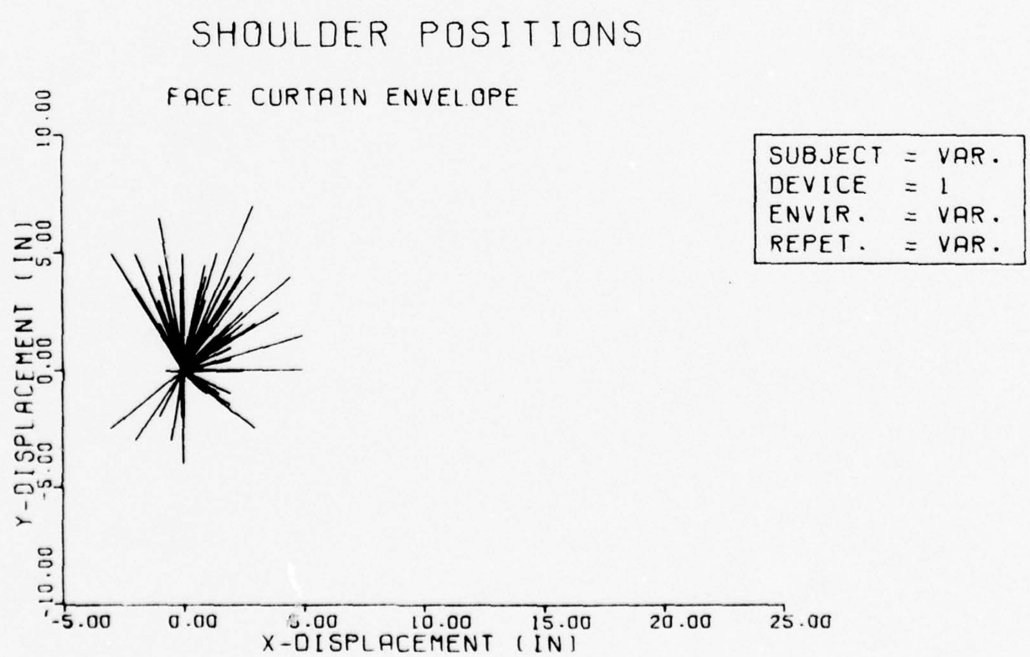

SHOULDER POSITIONS
FACE CURTAIN ENVELOPE
SUBJECT = VAR.
DEVICE = 1
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART B-21

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APPENDIX C

GRAPHS OF POSITIONS (TORSO HARNESS STRAPS TIGHT)

GROUPED ACCORDING TO THE FOLLOWING COMBINATIONS:

Subject No.		Chart No.
1	Environment -Gz	1
1	Environment -2.5Gx	2
3	Environment -Gz	3
3	Environment -2.5Gx	4
Environment -Gz, Device - Lower Ejection Handle		5
Environment -2.5Gx, Device - Lower Ejection Handle		6
Environment -Gz, Device - Face Curtain		7
Environment -2.5Gx, Device - Face Curtain		8

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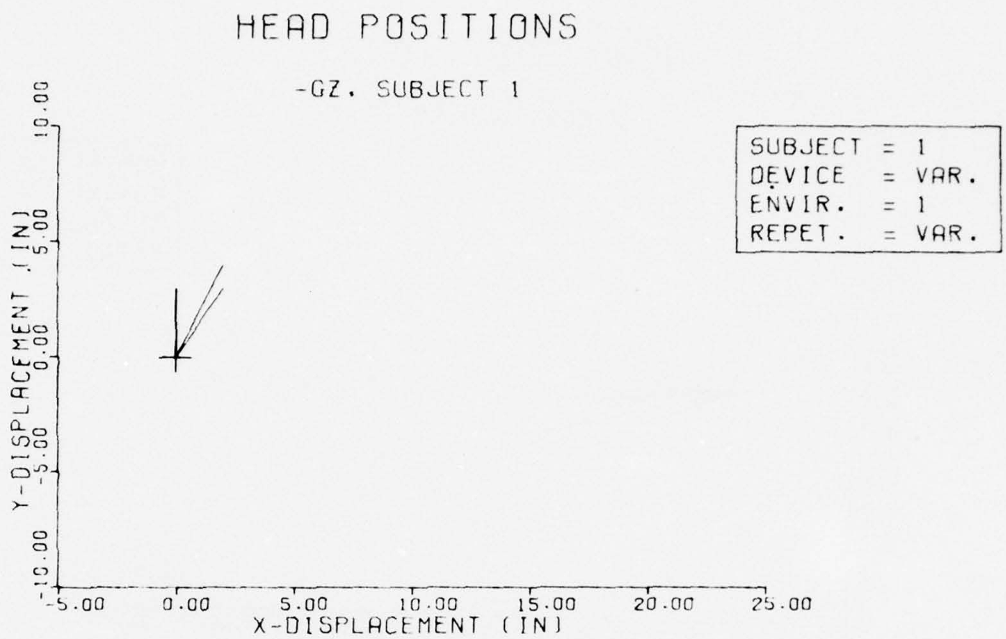

HEAD POSITIONS
-GZ. SUBJECT 1
SUBJECT = 1
DEVICE = VAR.
ENVIR. = 1
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

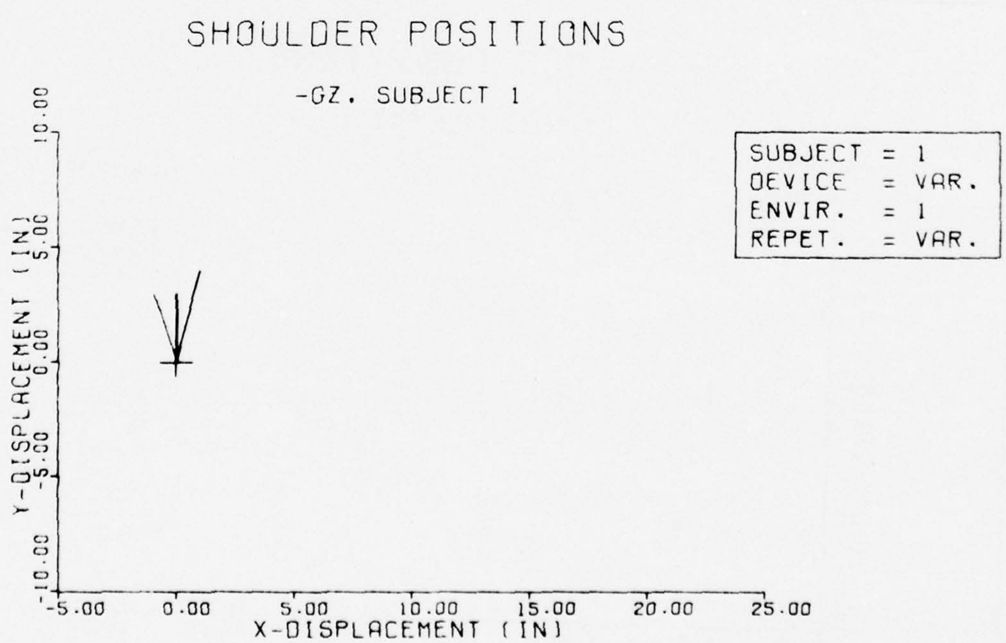
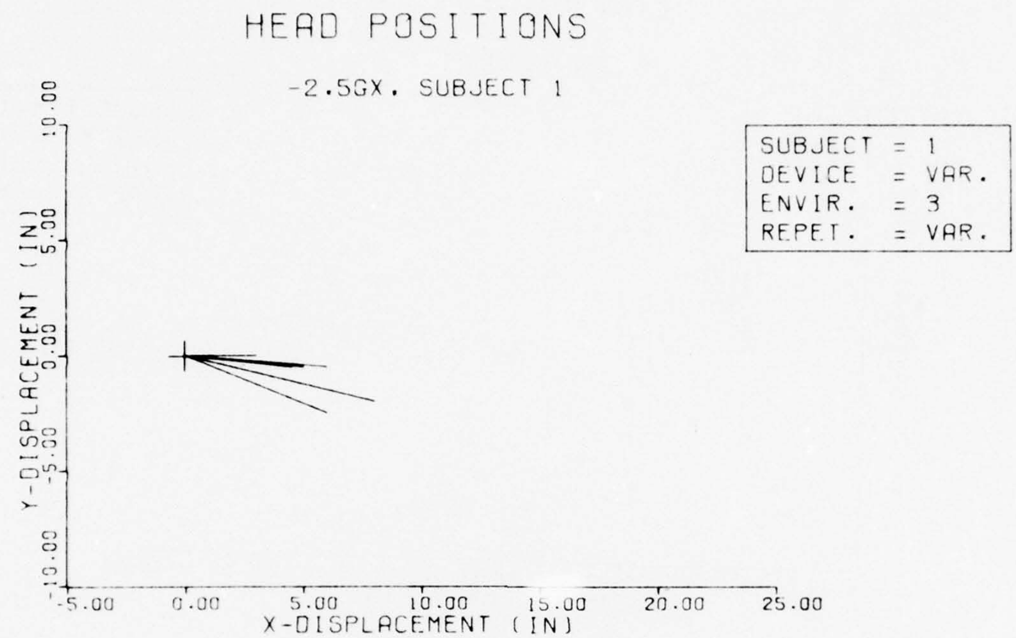

SHOULDER POSITIONS
-GZ. SUBJECT 1
SUBJECT = 1
DEVICE = VAR.
ENVIR. = 1
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART C-1


HEAD POSITIONS
-2.5GX. SUBJECT 1
SUBJECT = 1
DEVICE = VAR.
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

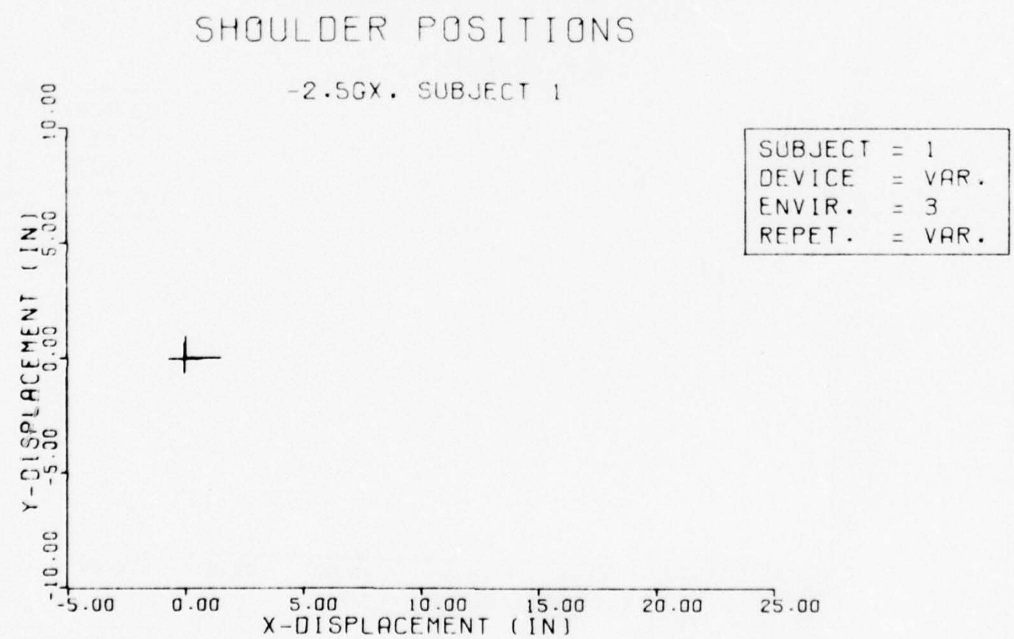
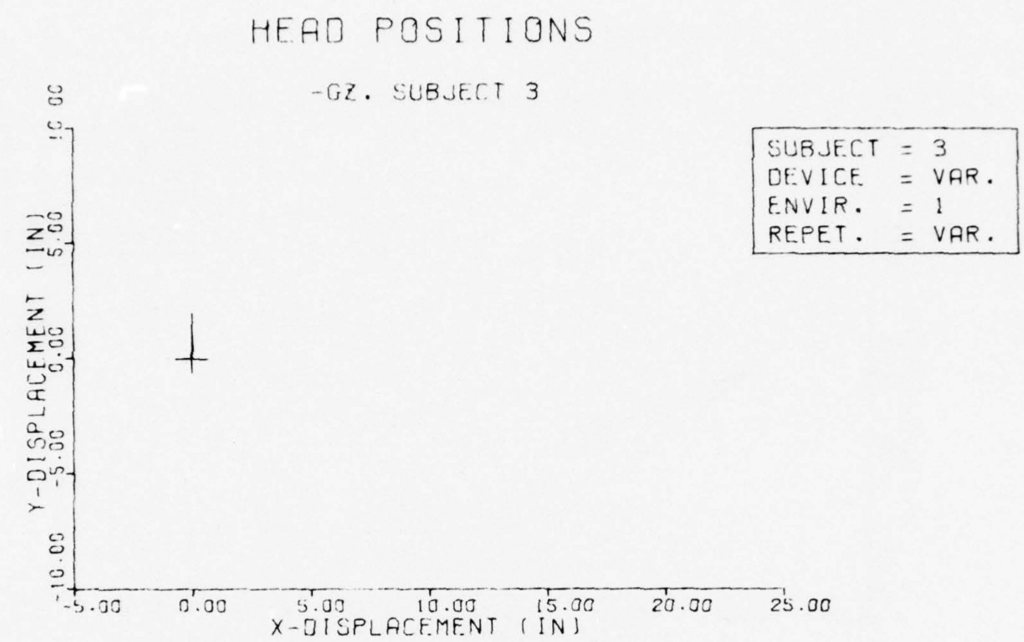

SHOULDER POSITIONS
-2.5GX. SUBJECT 1
SUBJECT = 1
DEVICE = VAR.
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART C-2


HEAD POSITIONS
-GZ. SUBJECT 3
SUBJECT = 3
DEVICE = VAR.
ENVIR. = 1
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

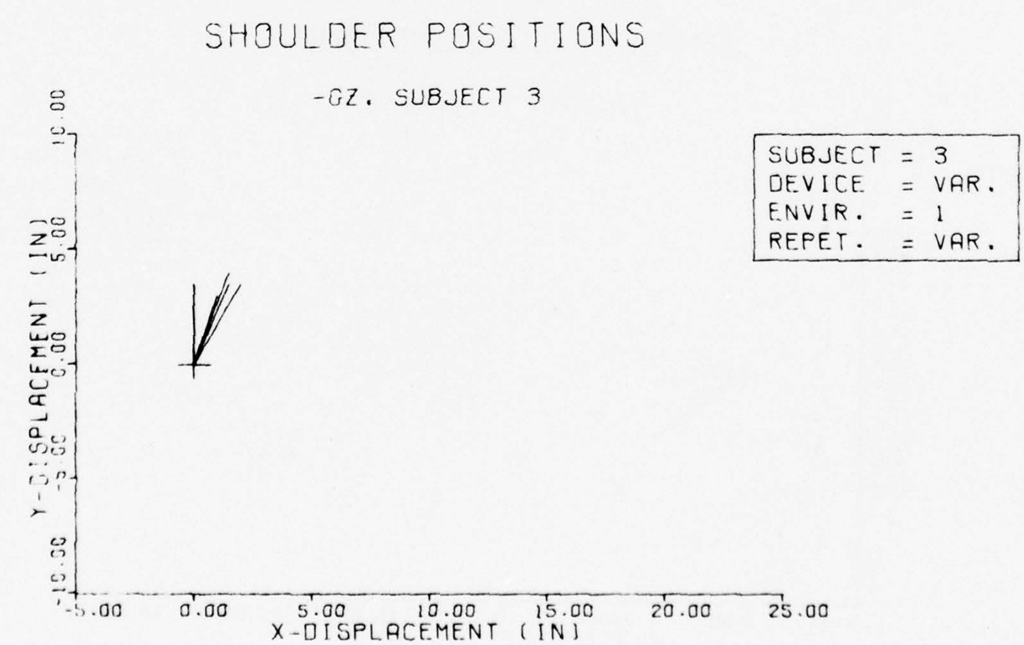
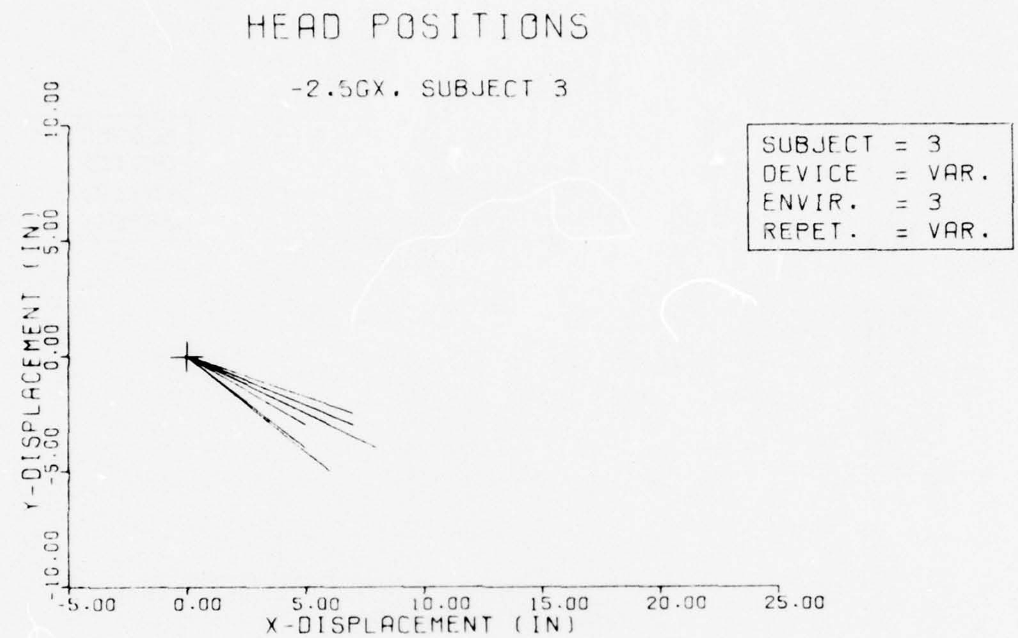

SHOULDER POSITIONS
-GZ. SUBJECT 3
SUBJECT = 3
DEVICE = VAR.
ENVIR. = 1
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART C-3


HEAD POSITIONS
-2.5GX. SUBJECT 3
SUBJECT = 3
DEVICE = VAR.
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

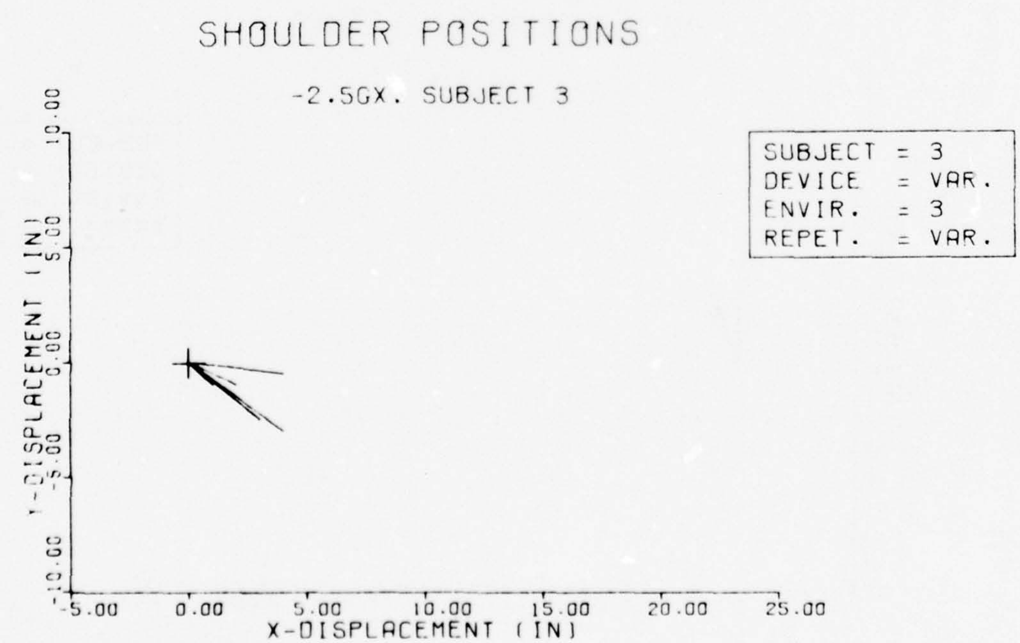
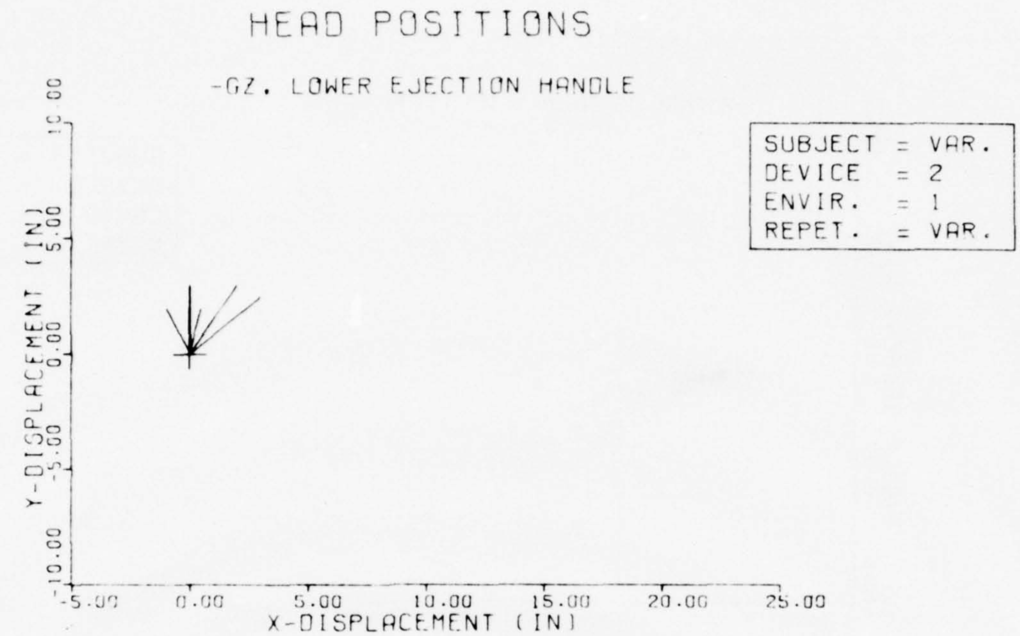

SHOULDER POSITIONS
-2.5GX. SUBJECT 3
SUBJECT = 3
DEVICE = VAR.
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART C-4


HEAD POSITIONS
-GZ. LOWER EJECTION HANDLE
SUBJECT = VAR.
DEVICE = 2
ENVIR. = 1
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

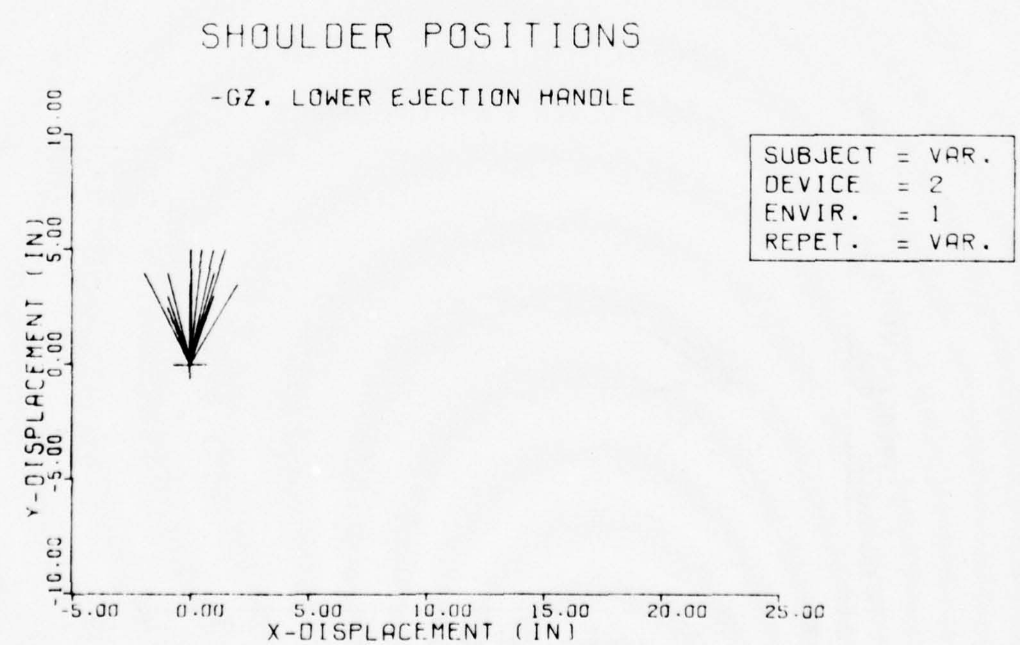
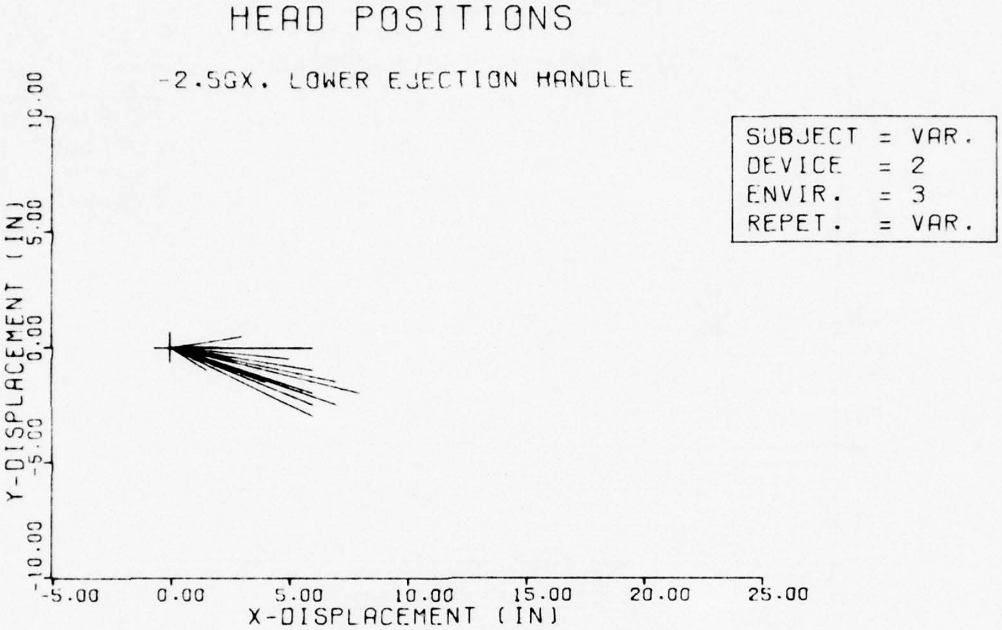

SHOULDER POSITIONS
-GZ. LOWER EJECTION HANDLE
SUBJECT = VAR.
DEVICE = 2
ENVIR. = 1
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART C-5


HEAD POSITIONS
-2.5GX. LOWER EJECTION HANDLE
SUBJECT = VAR.
DEVICE = 2
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

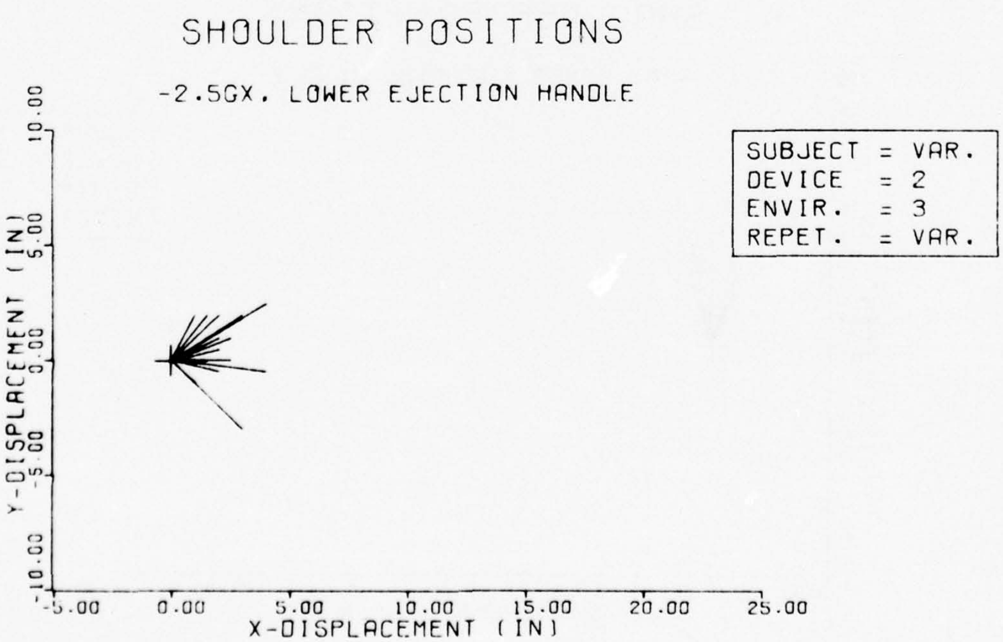
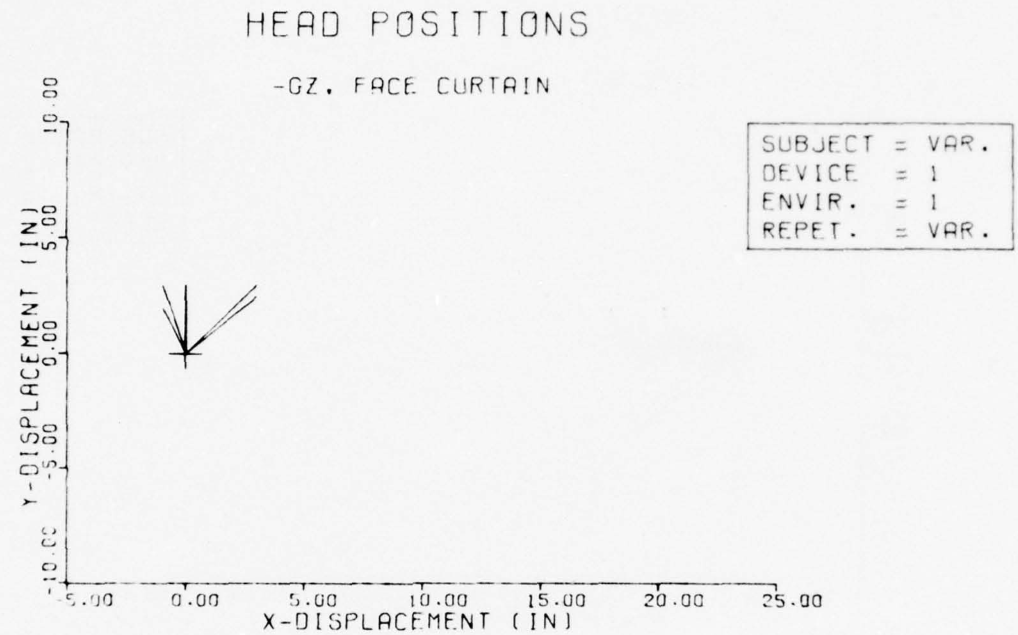

SHOULDER POSITIONS
-2.5GX. LOWER EJECTION HANDLE
SUBJECT = VAR.
DEVICE = 2
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART C-6


HEAD POSITIONS
-GZ. FACE CURTAIN
SUBJECT = VAR.
DEVICE = 1
ENVIR. = 1
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)
-10.00
-5.00
0.00
5.00
10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00

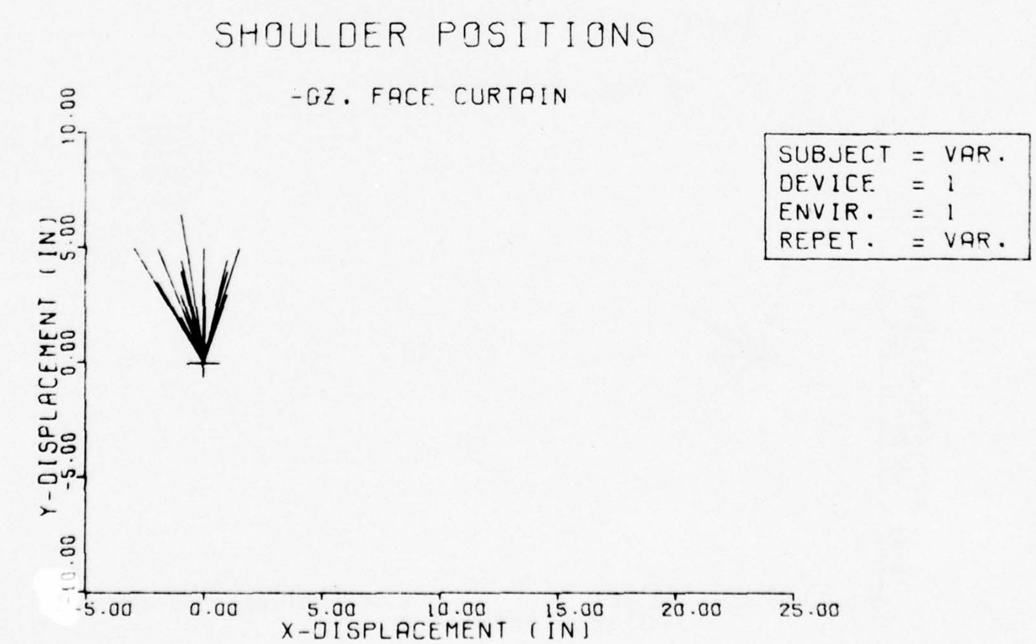
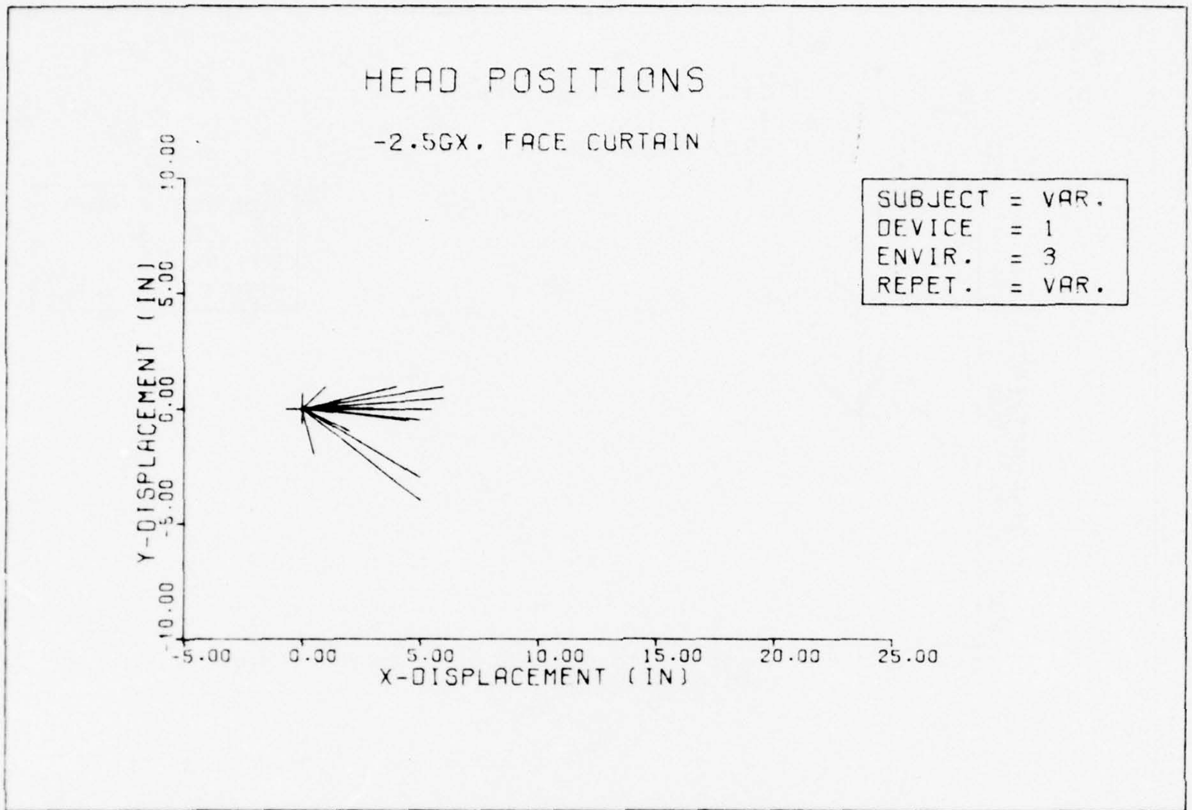

SHOULDER POSITIONS
-GZ. FACE CURTAIN
SUBJECT = VAR.
DEVICE = 1
ENVIR. = 1
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)
-10.00
-5.00
0.00
5.00
10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00

CHART C-7


HEAD POSITIONS
-2.5GX, FACE CURTAIN
SUBJECT = VAR.
DEVICE = 1
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

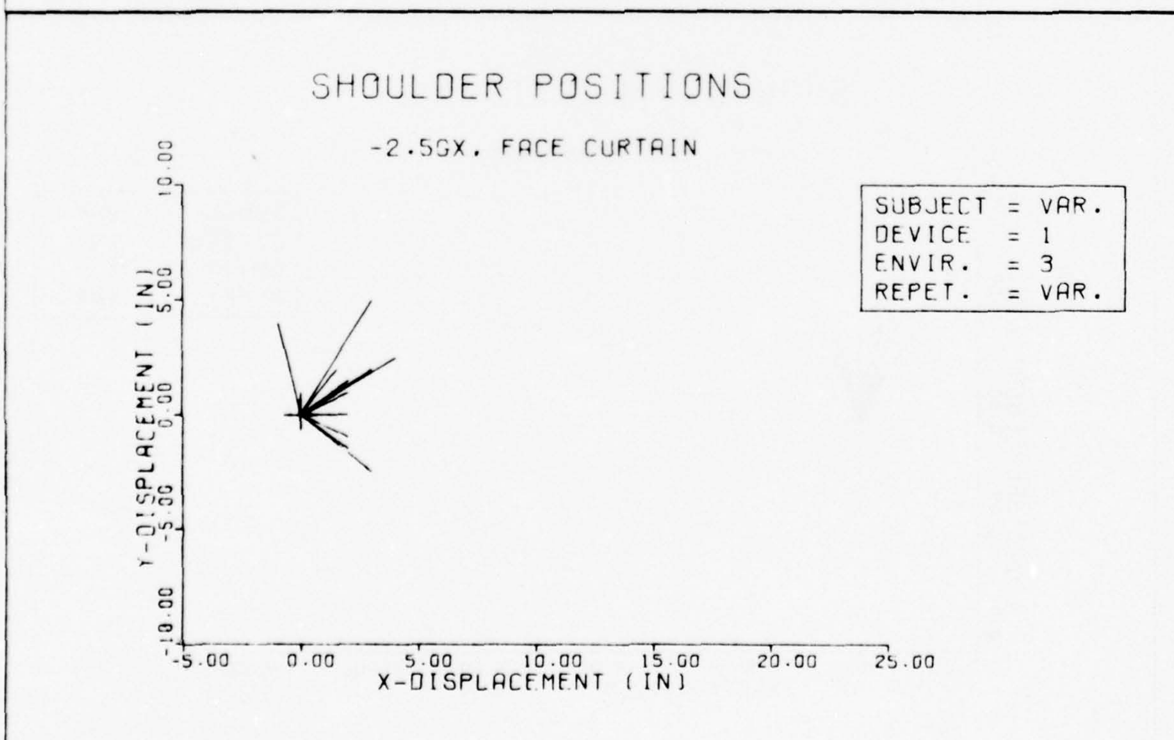

SHOULDER POSITIONS
-2.5GX, FACE CURTAIN
SUBJECT = VAR.
DEVICE = 1
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART C-8

APPENDIX D

GRAPHS OF POSITIONS (TORSO HARNESS STRAPS LOOSE) GROUPED ACCORDING TO:

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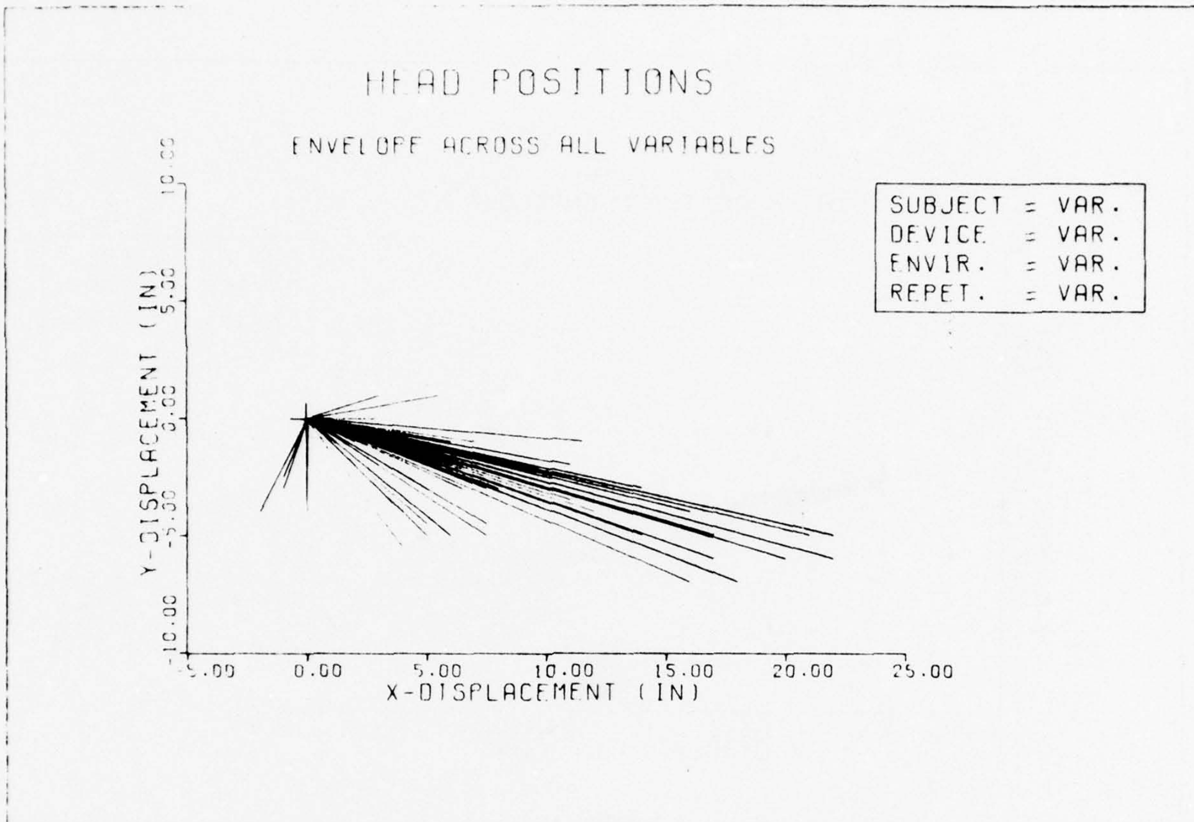

HEAD POSITIONS
ENVELOPE ACROSS ALL VARIABLES
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

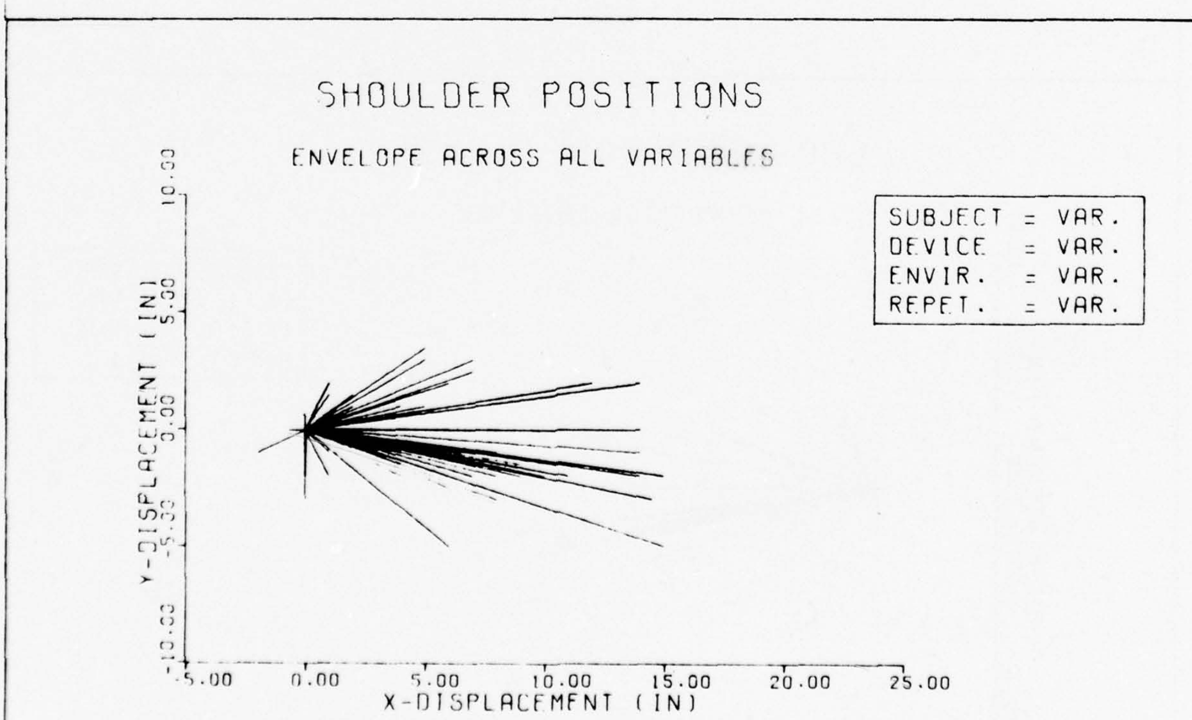
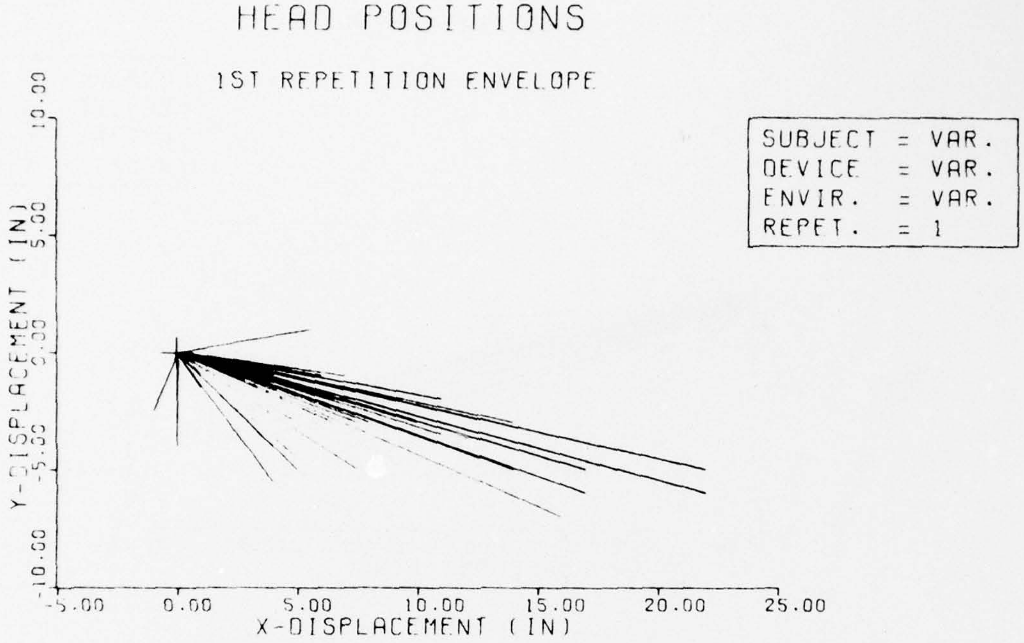

SHOULDER POSITIONS
ENVELOPE ACROSS ALL VARIABLES
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-1


HEAD POSITIONS
1ST REPETITION ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = VAR.
REPET. = 1
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

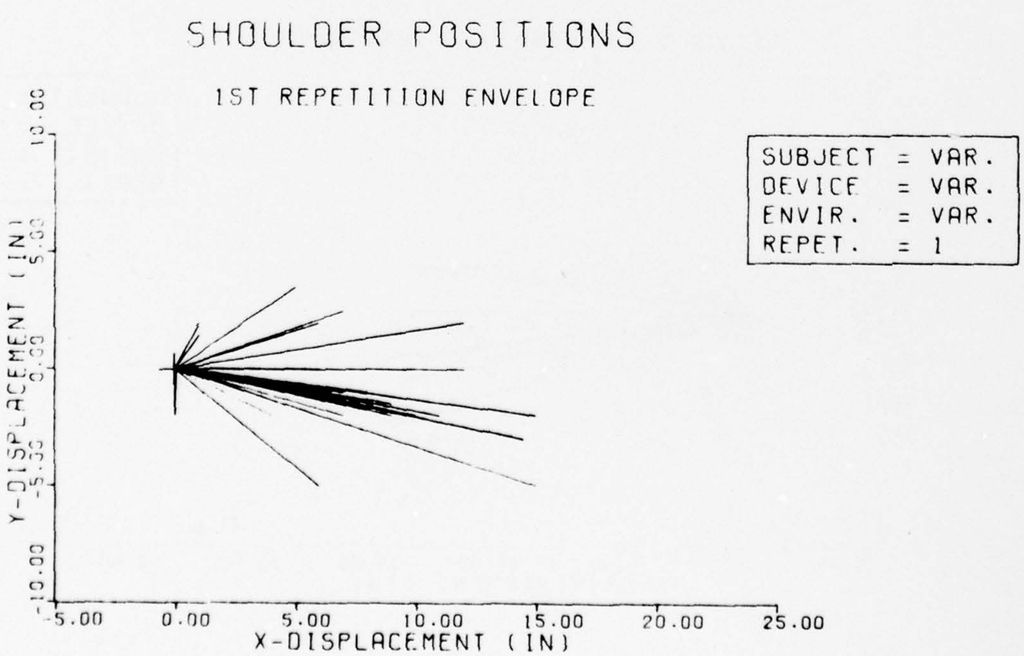
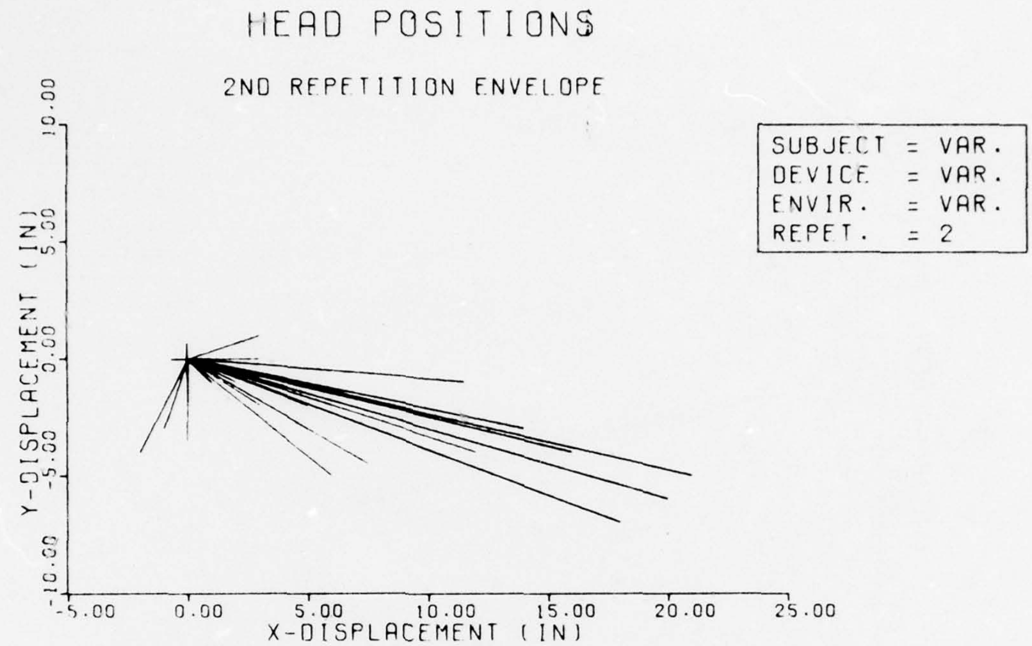

SHOULDER POSITIONS
1ST REPETITION ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = VAR.
REPET. = 1
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-2


HEAD POSITIONS
2ND REPETITION ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = VAR.
REPET. = 2
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

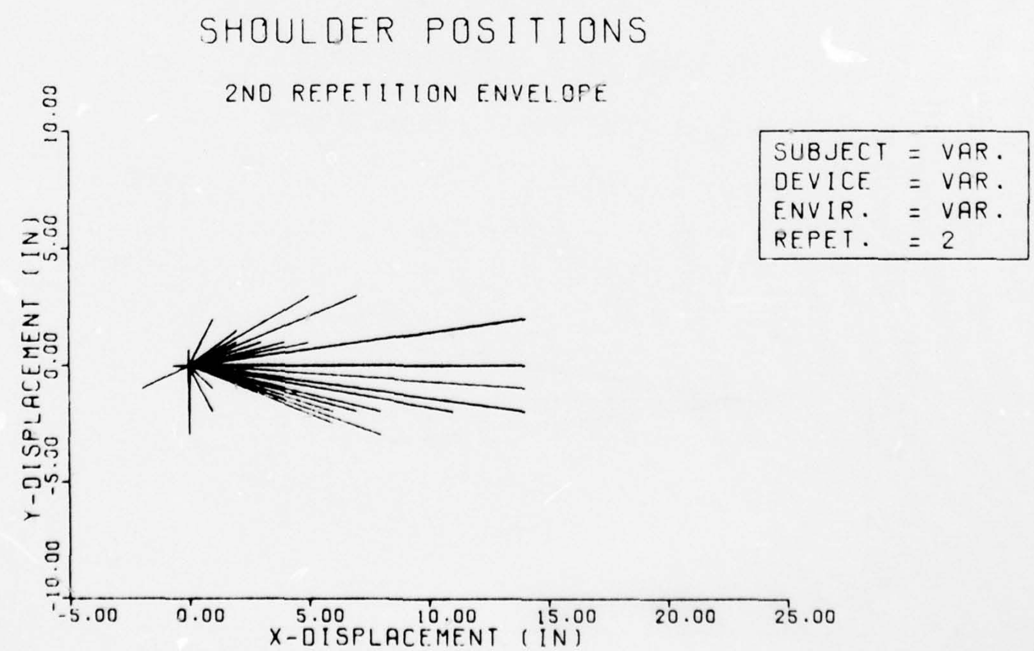
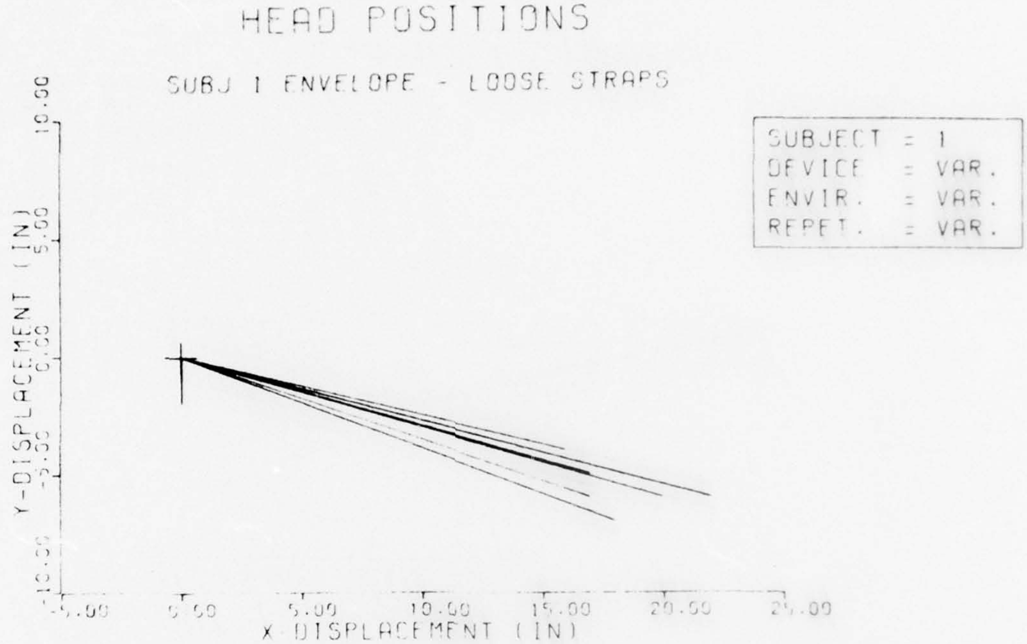

SHOULDER POSITIONS
2ND REPETITION ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = VAR.
REPET. = 2
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-3


HEAD POSITIONS
SUBJ 1 ENVELOPE - LOOSE STRAPS
SUBJECT = 1
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)

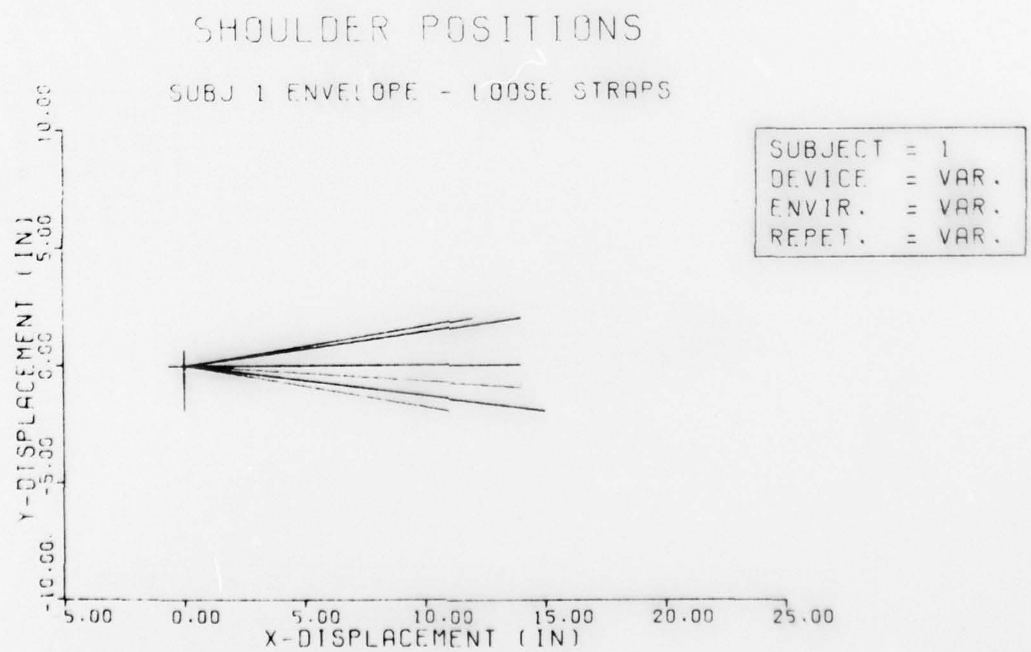
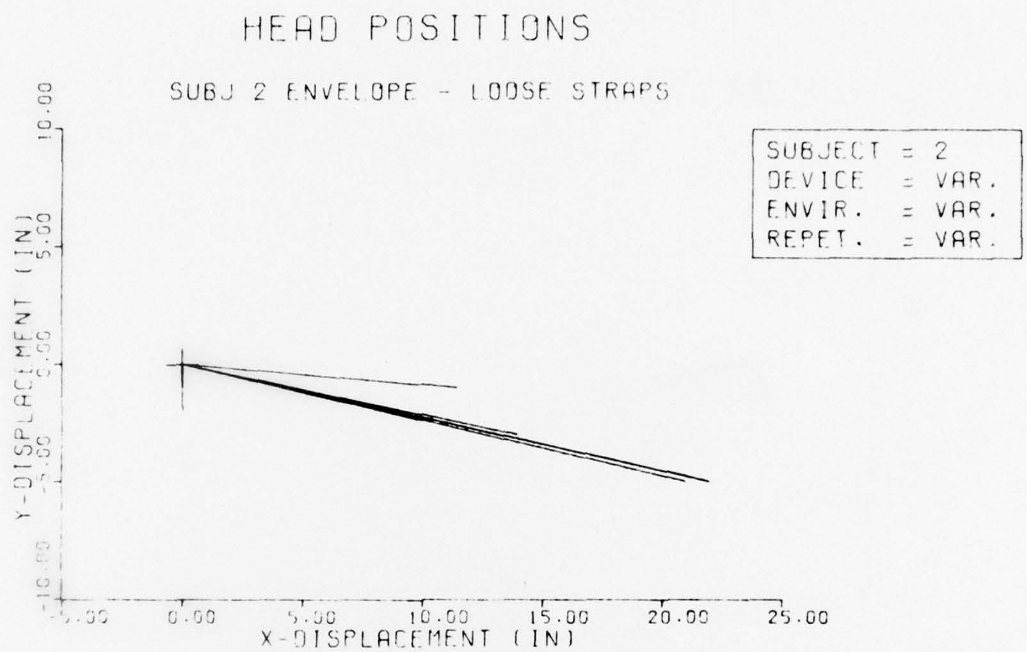

SHOULDER POSITIONS
SUBJ 1 ENVELOPE - LOOSE STRAPS
SUBJECT = 1
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
-10.00
-5.00
0.00
5.00
10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-4


HEAD POSITIONS
SUBJ 2 ENVELOPE - LOOSE STRAPS
SUBJECT = 2
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00

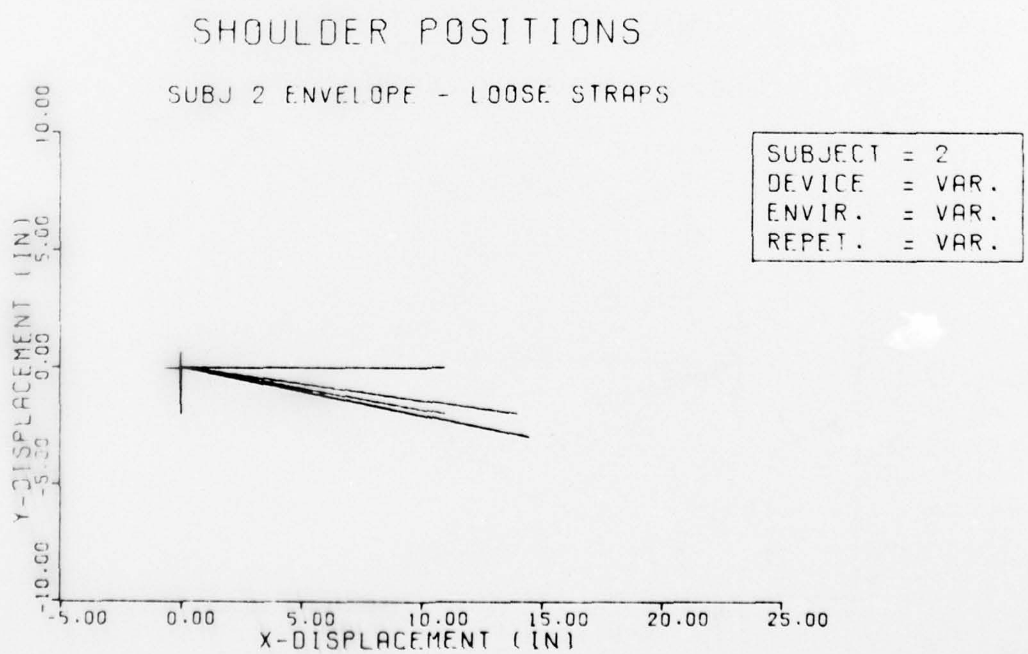
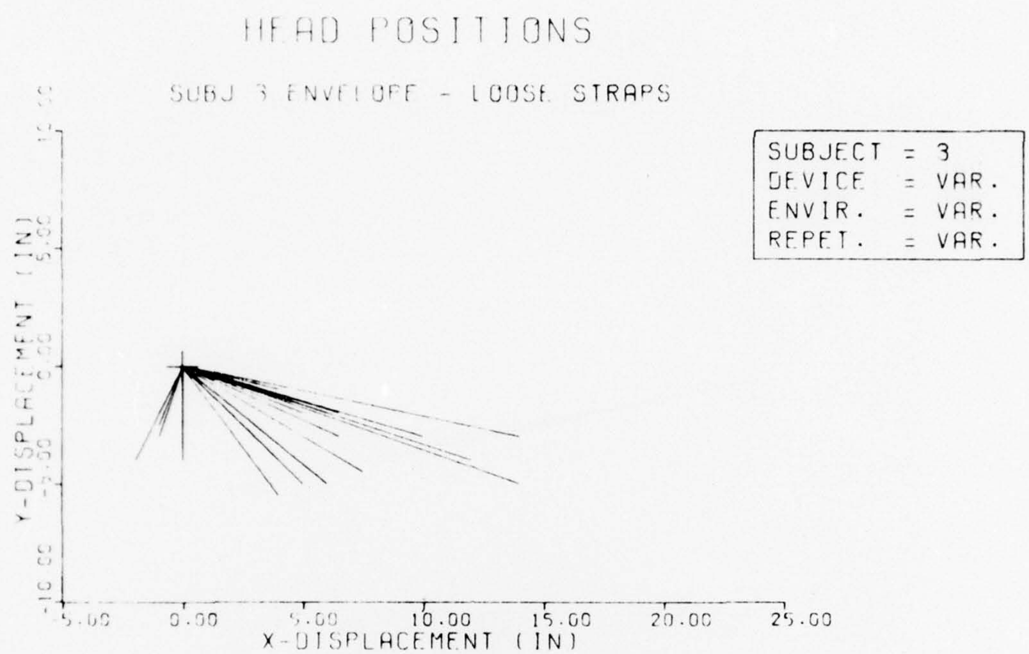

SHOULDER POSITIONS
SUBJ 2 ENVELOPE - LOOSE STRAPS
SUBJECT = 2
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00

CHART D-5


HEAD POSITIONS
SUBJ 3 ENVELOPE - LOOSE STRAPS
SUBJECT = 3
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
-10.00
-5.00
0.00
5.00

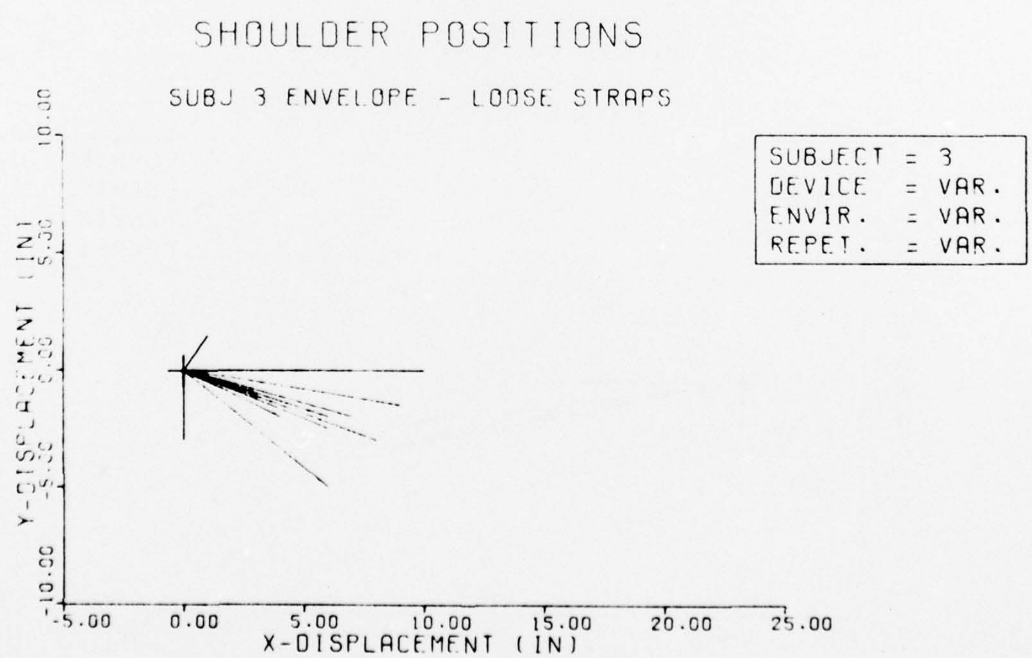
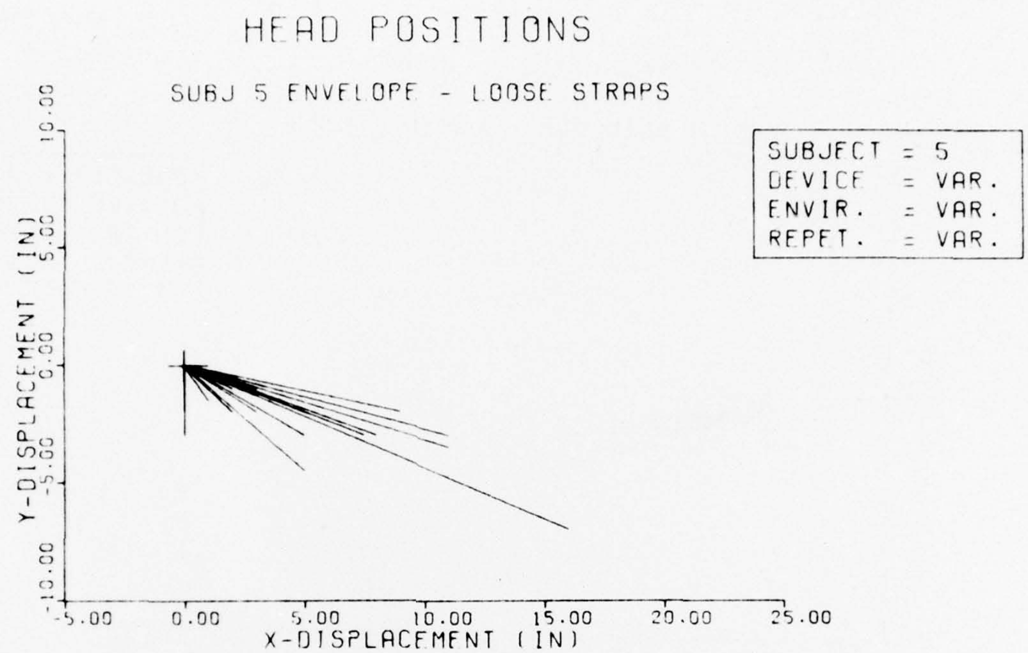
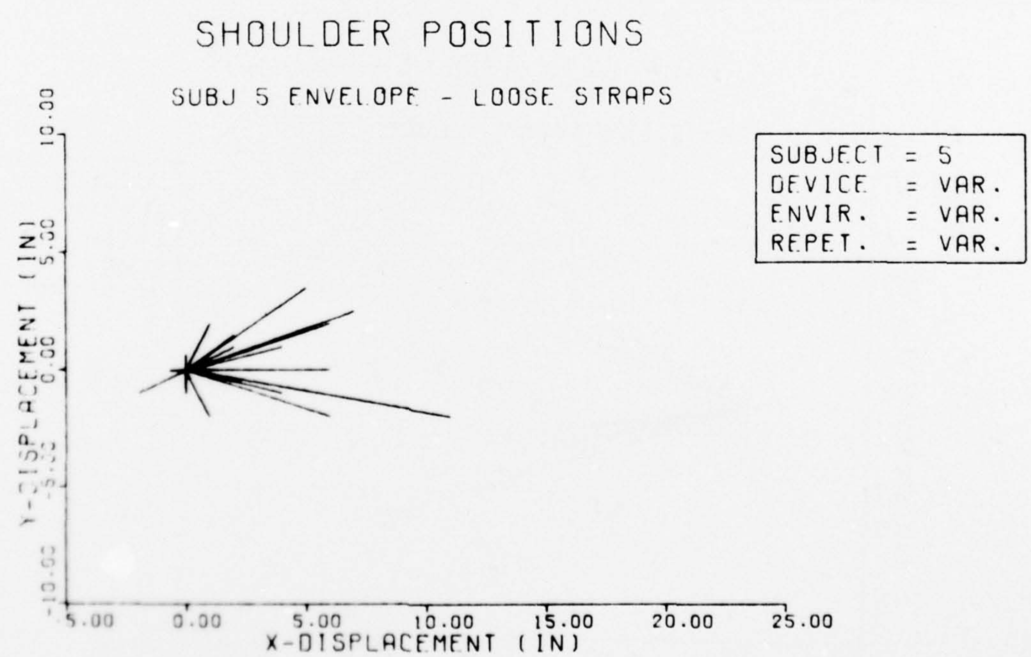

SHOULDER POSITIONS
SUBJ 3 ENVELOPE - LOOSE STRAPS
SUBJECT = 3
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
-10.00
-5.00
0.00
5.00
10.00

CHART D-6

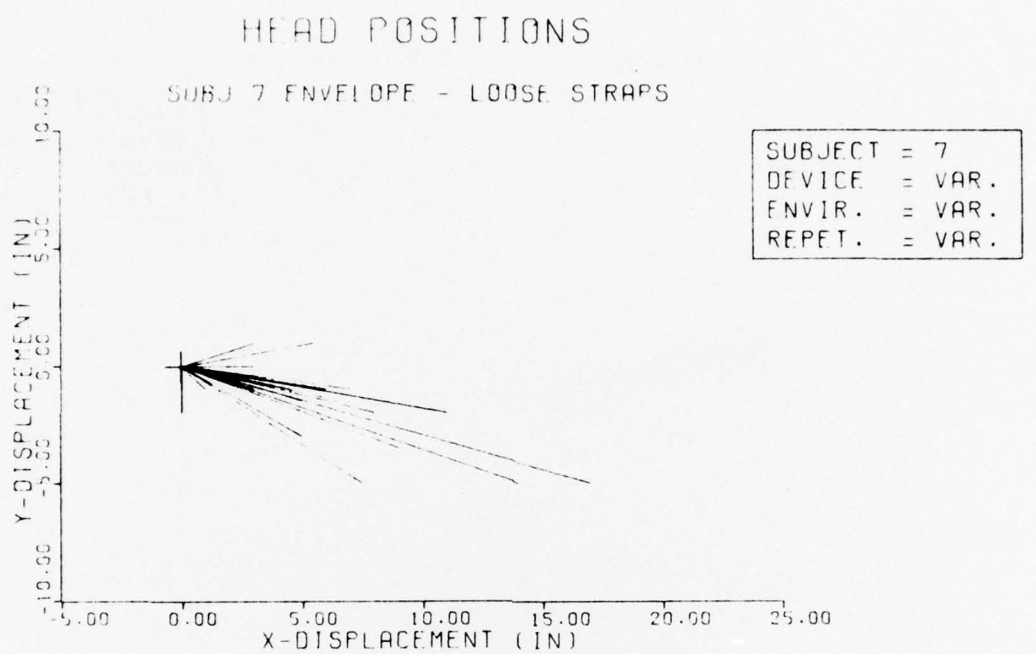


HEAD POSITIONS
SUBJ 5 ENVELOPE - LOOSE STRAPS
SUBJECT = 5
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00



SHOULDER POSITIONS
SUBJ 5 ENVELOPE - LOOSE STRAPS
SUBJECT = 5
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
X-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00

CHART D-7


HEAD POSITIONS
SUBJ 7 ENVELOPE - LOOSE STRAPS
SUBJECT = 7
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

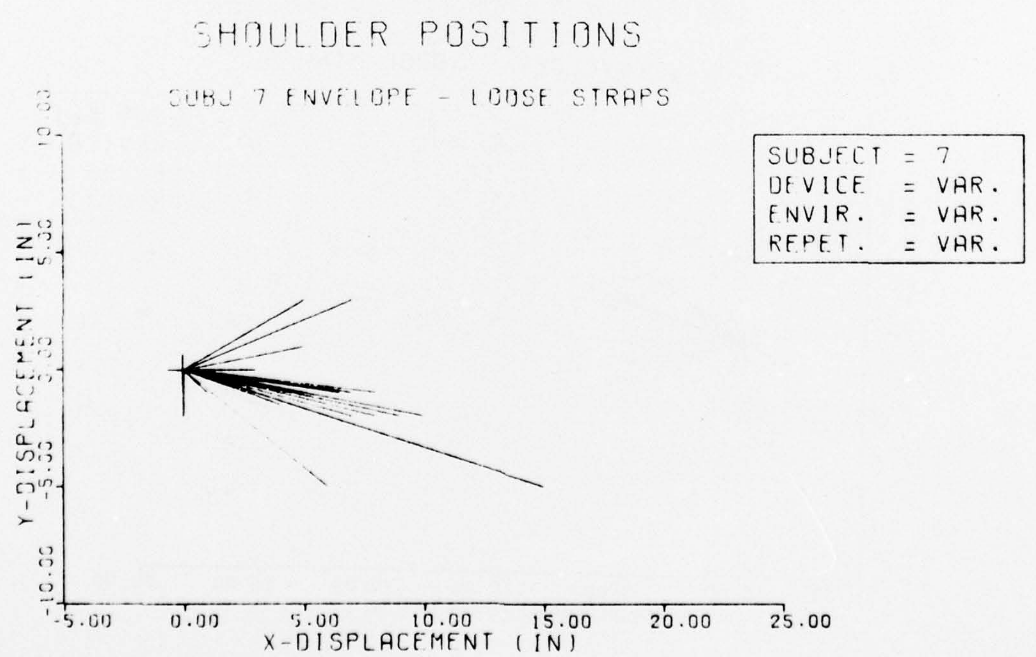
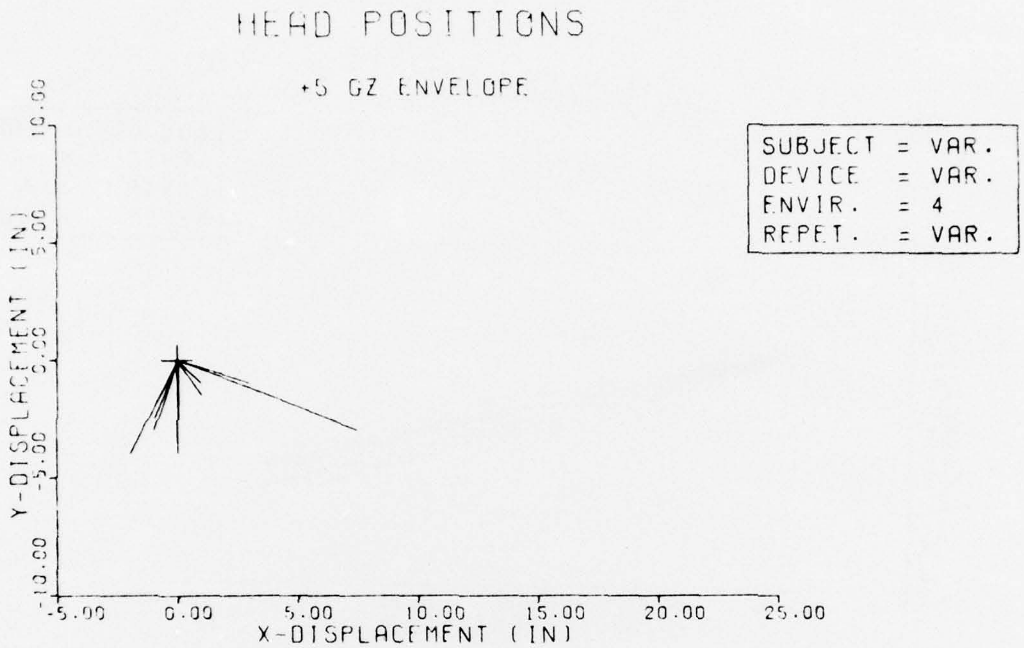

SHOULDER POSITIONS
SUBJ 7 ENVELOPE - LOOSE STRAPS
SUBJECT = 7
DEVICE = VAR.
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-8


HEAD POSITIONS
+5 GZ ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 4
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

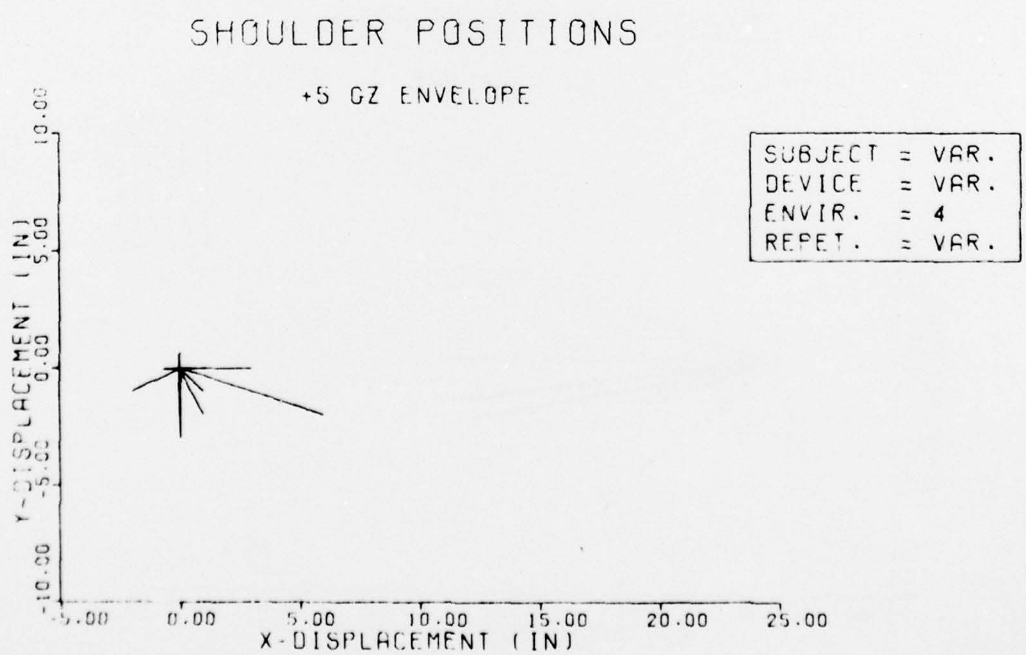
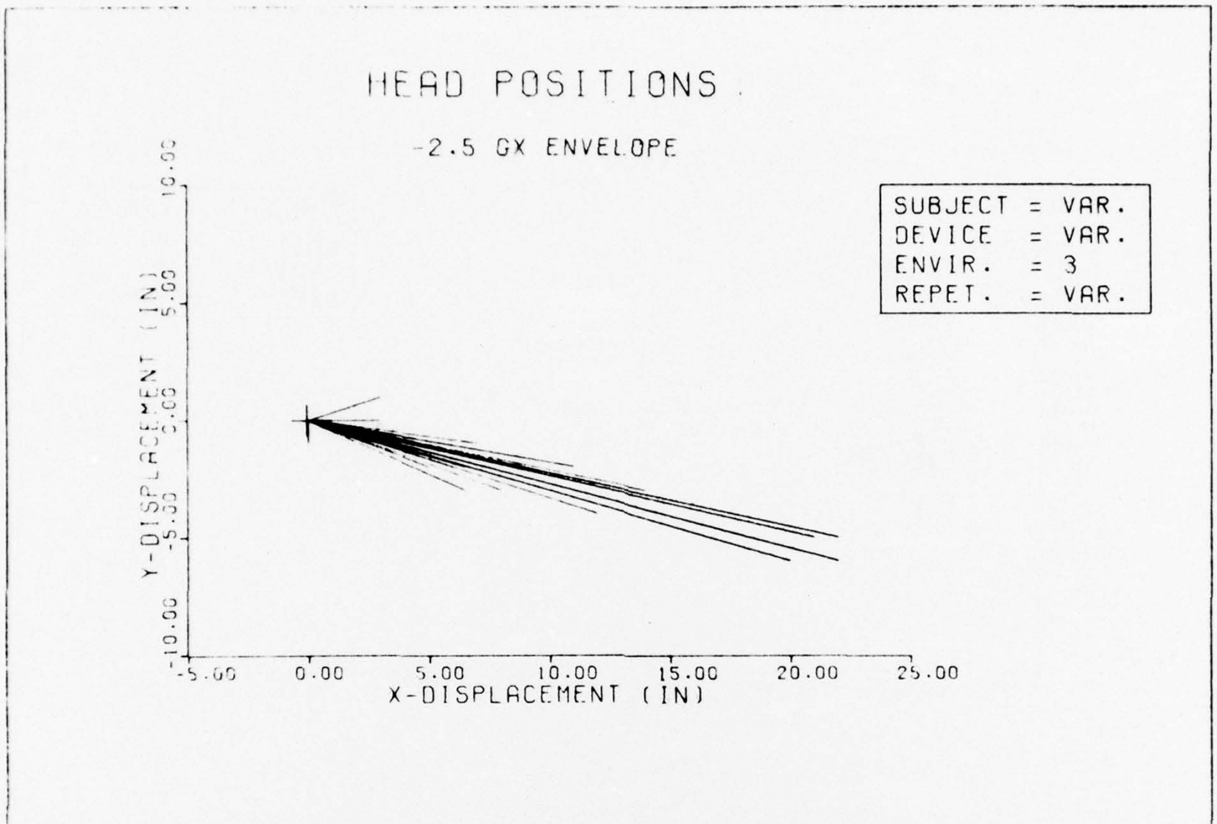

SHOULDER POSITIONS
+5 GZ ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 4
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-9


HEAD POSITIONS
-2.5 GX ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

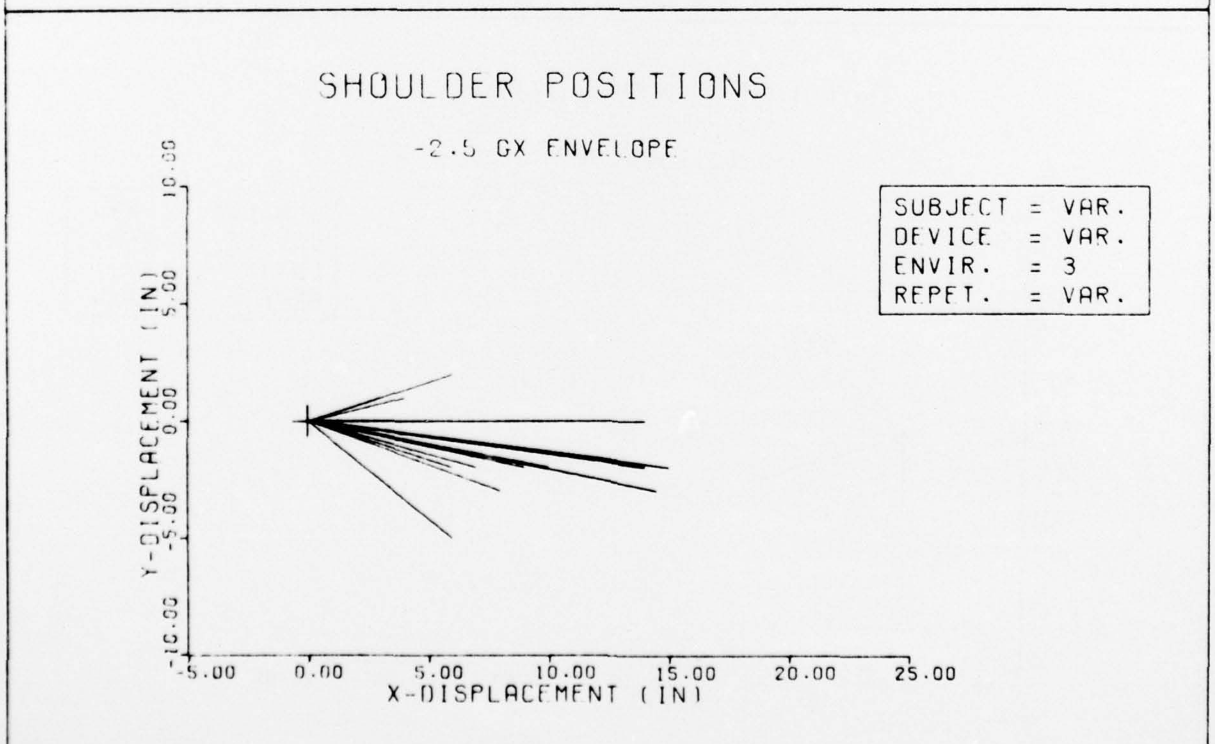
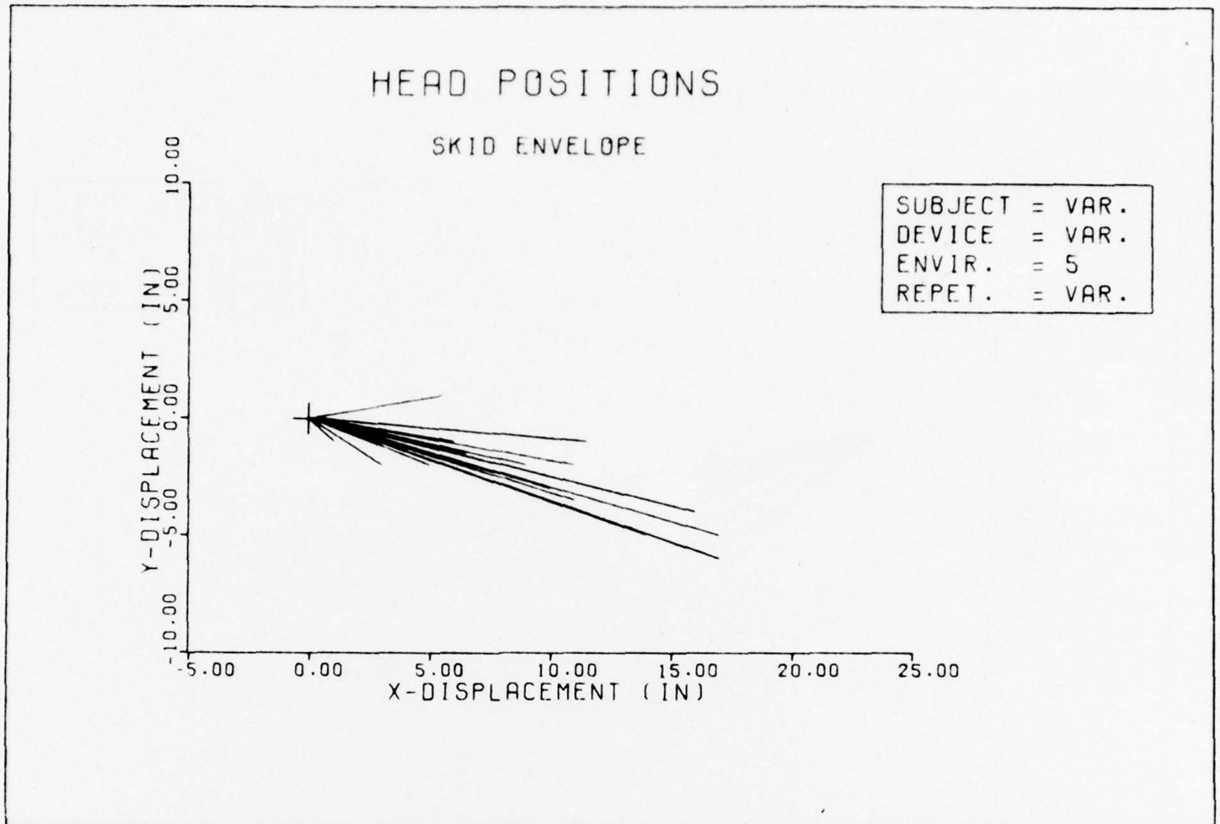

SHOULDER POSITIONS
-2.5 GX ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 3
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-10


HEAD POSITIONS
SKID ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 5
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

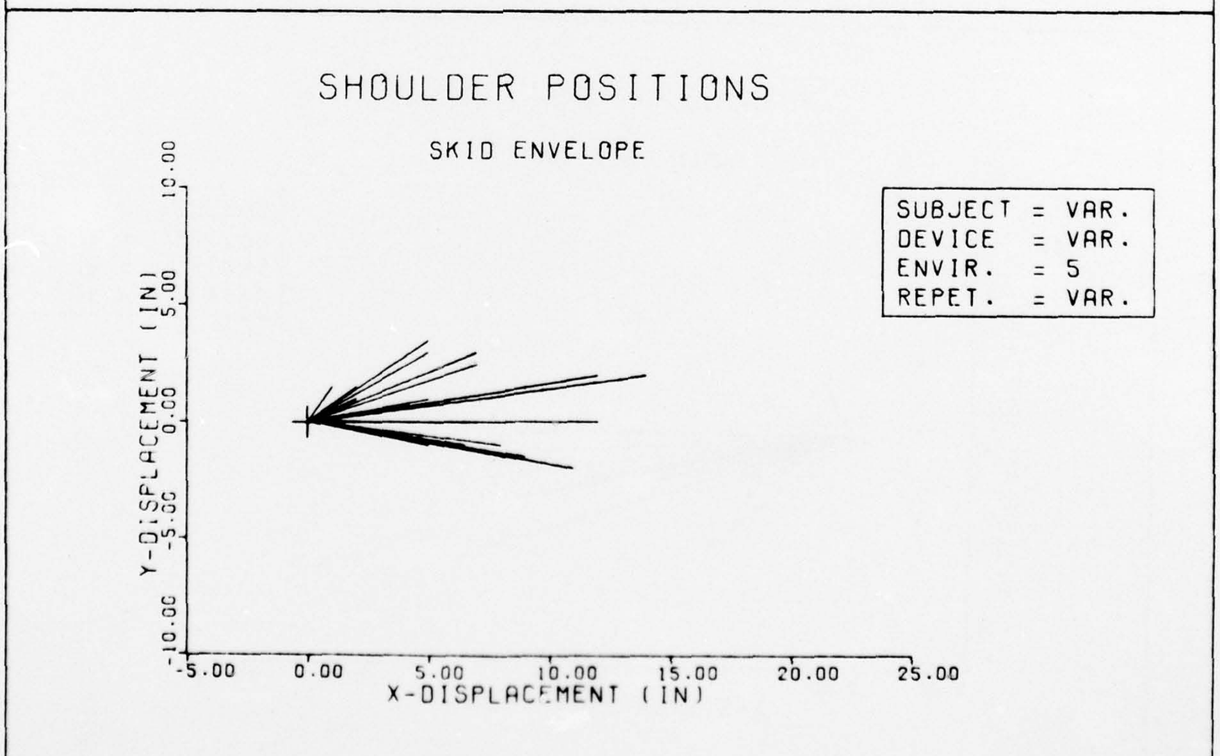
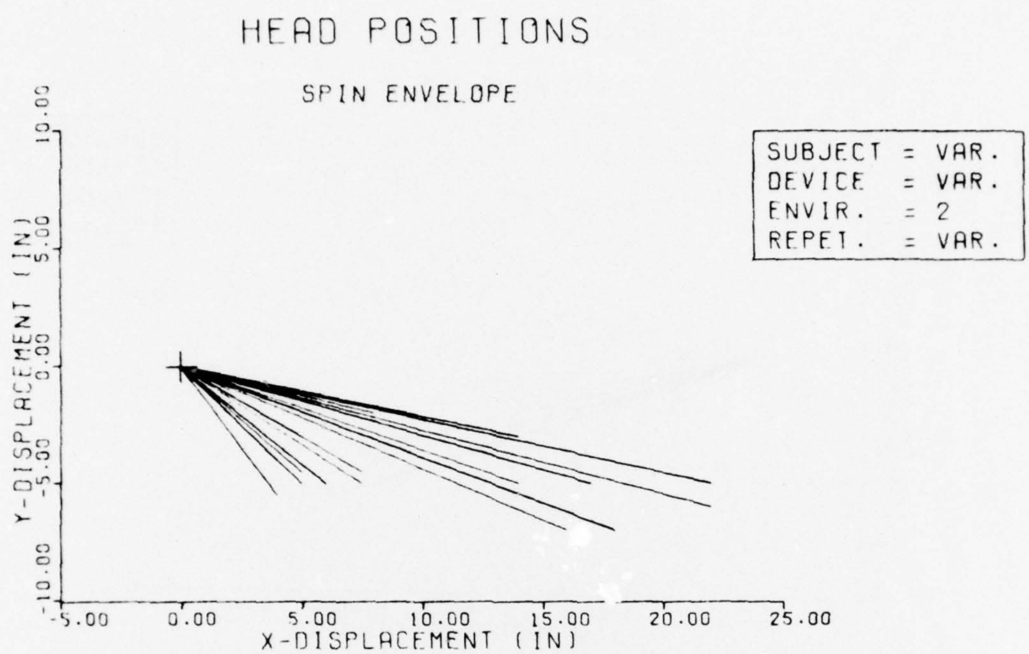
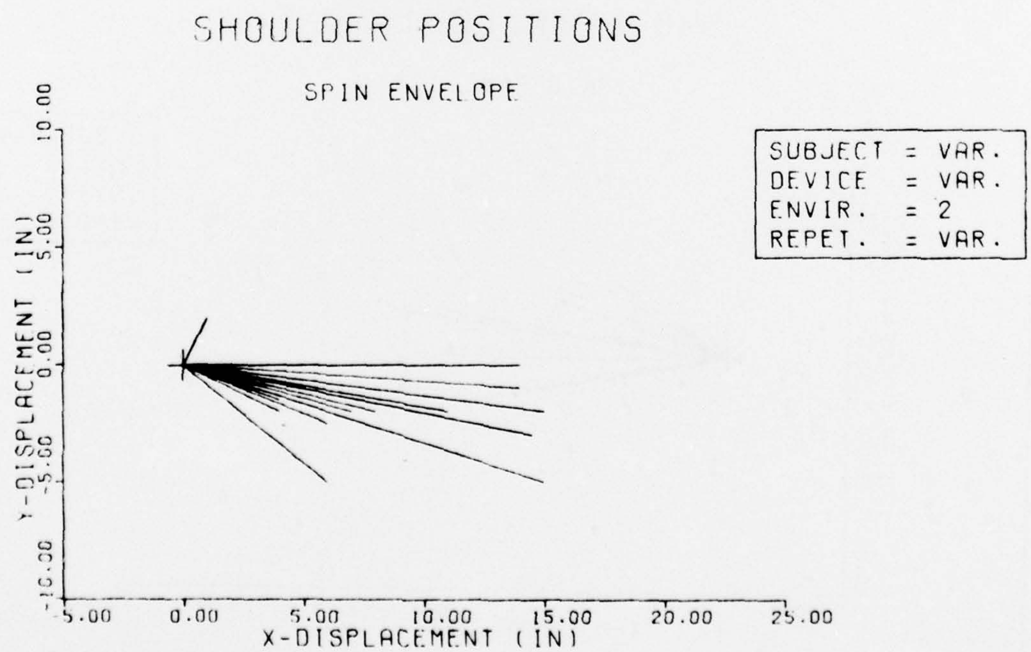

SHOULDER POSITIONS
SKID ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 5
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-11

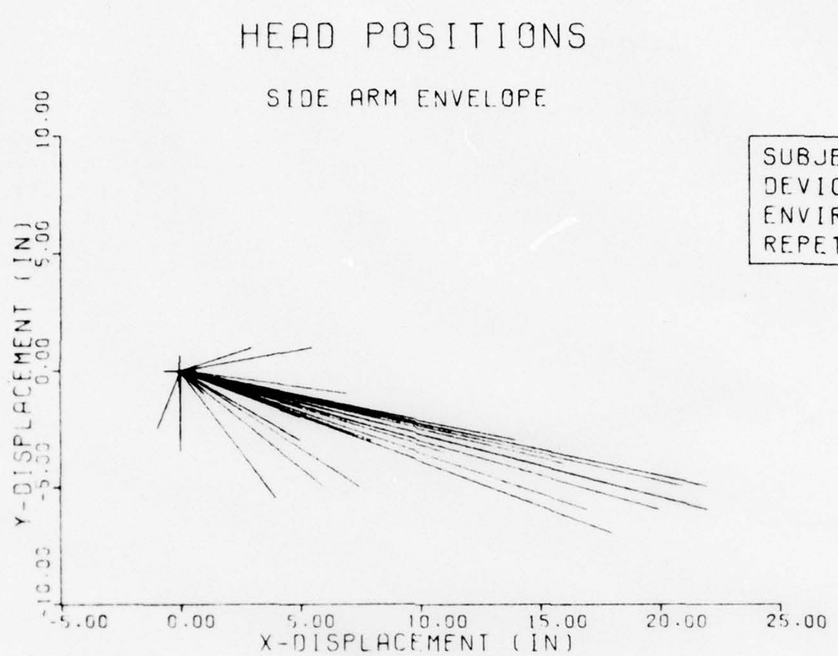


HEAD POSITIONS
SPIN ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 2
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)



SHOULDER POSITIONS
SPIN ENVELOPE
SUBJECT = VAR.
DEVICE = VAR.
ENVIR. = 2
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-12


HEAD POSITIONS
SIDE ARM ENVELOPE
SUBJECT = VAR.
DEVICE = 4
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

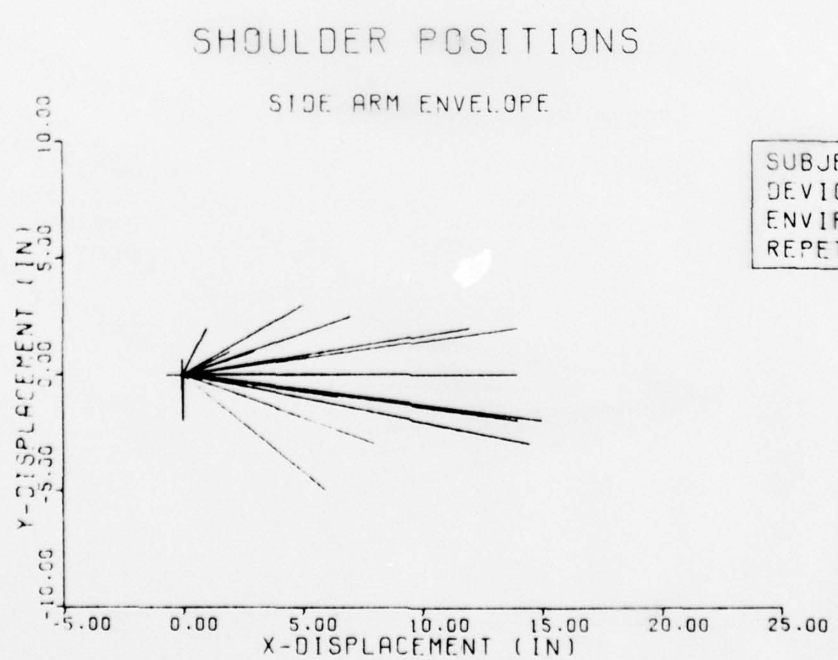
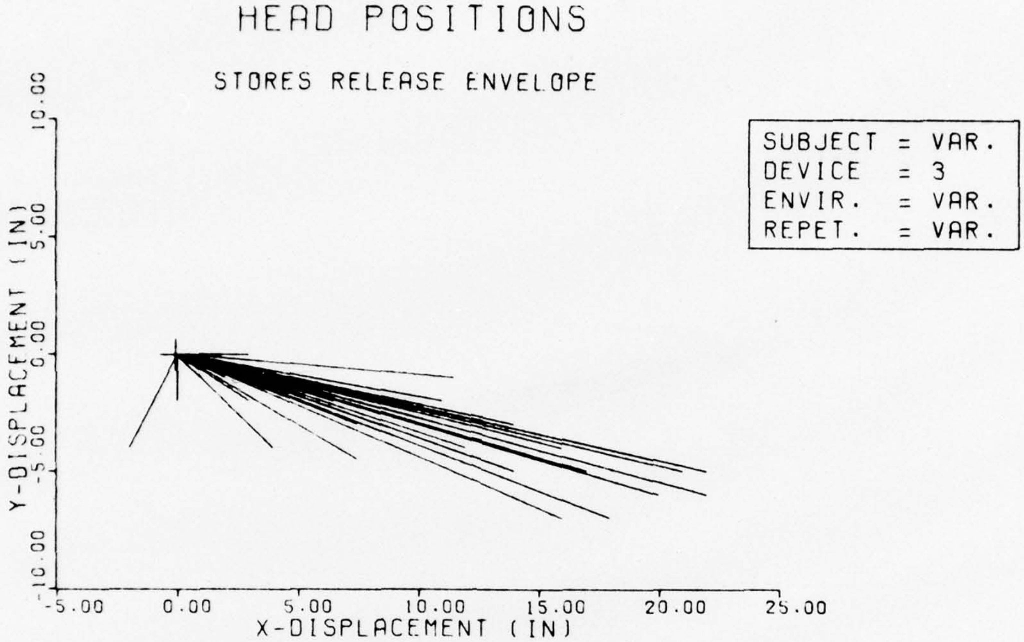

SHOULDER POSITIONS
SIDE ARM ENVELOPE
SUBJECT = VAR.
DEVICE = 4
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-13


HEAD POSITIONS
STORES RELEASE ENVELOPE
SUBJECT = VAR.
DEVICE = 3
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

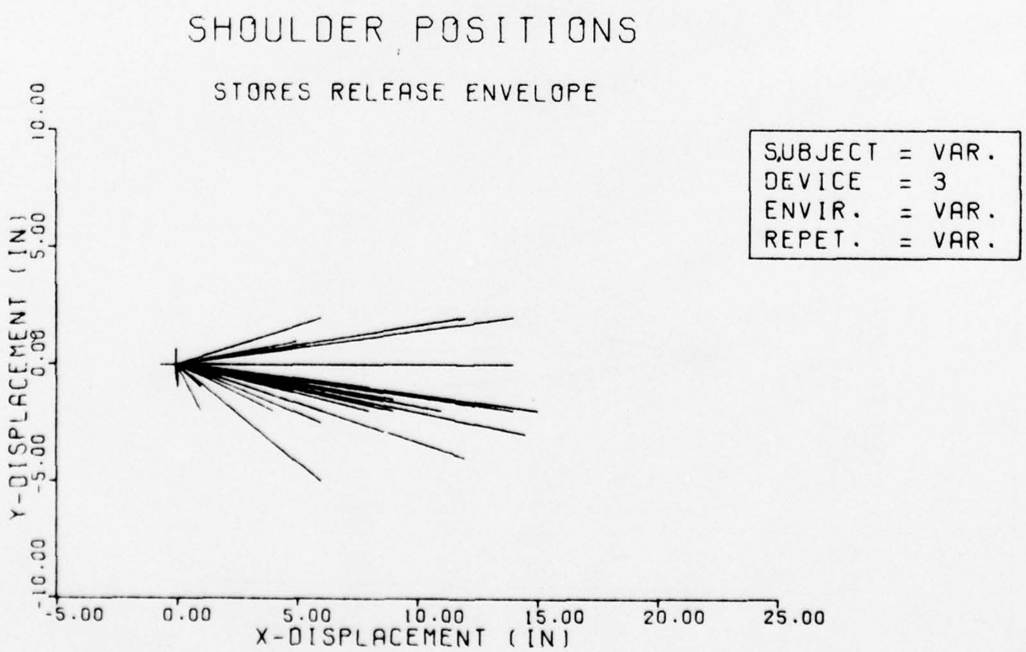
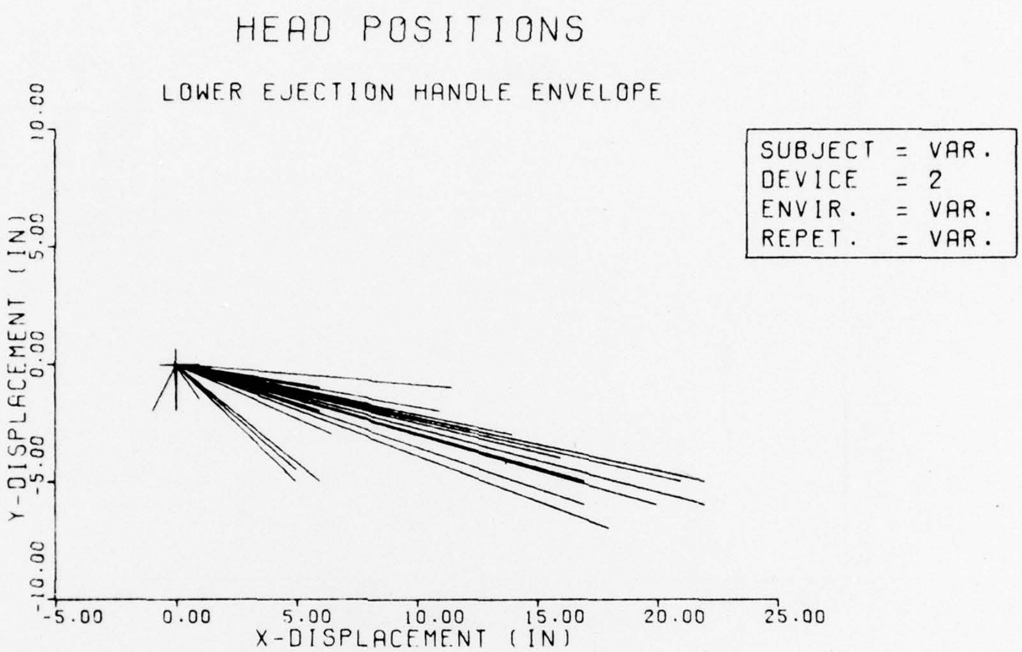

SHOULDER POSITIONS
STORES RELEASE ENVELOPE
SUBJECT = VAR.
DEVICE = 3
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-14


HEAD POSITIONS
LOWER EJECTION HANDLE ENVELOPE
SUBJECT = VAR.
DEVICE = 2
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

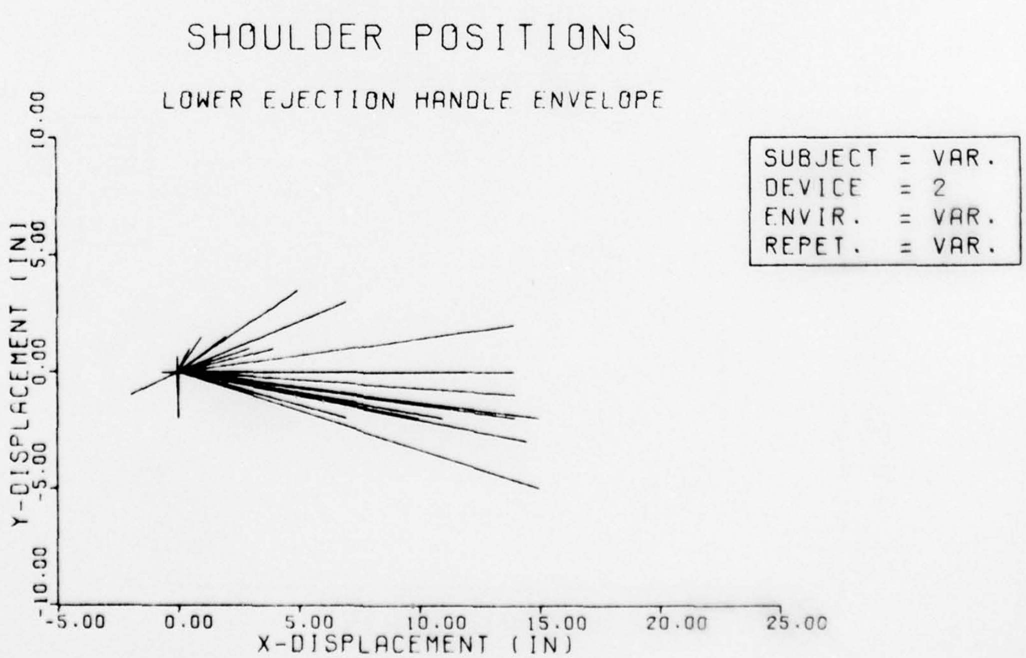
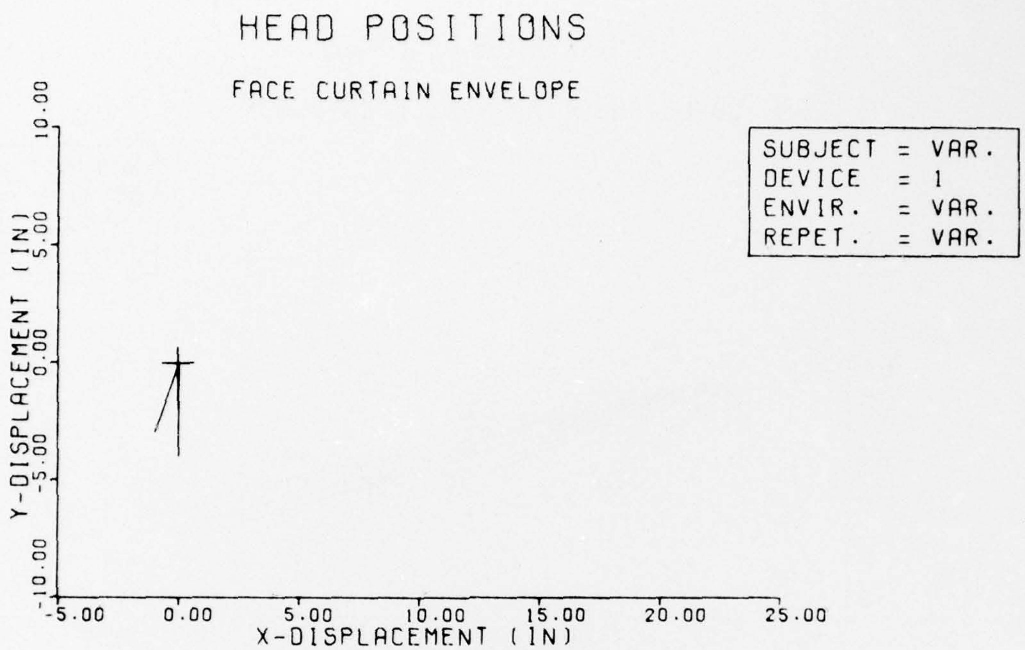

SHOULDER POSITIONS
LOWER EJECTION HANDLE ENVELOPE
SUBJECT = VAR.
DEVICE = 2
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART D-15


HEAD POSITIONS
FACE CURTAIN ENVELOPE
SUBJECT = VAR.
DEVICE = 1
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

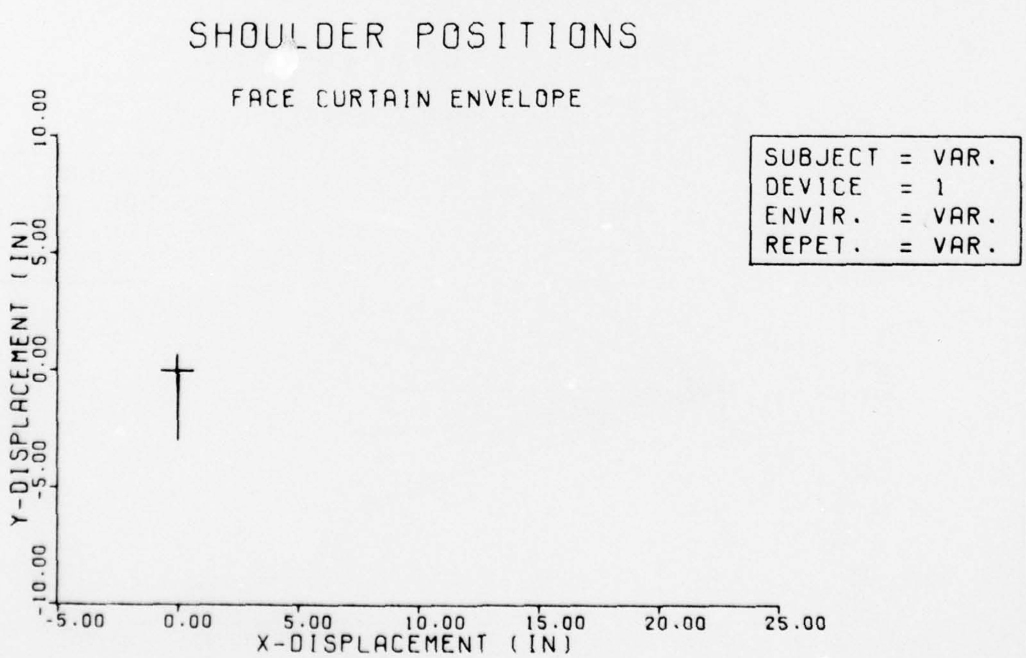

SHOULDER POSITIONS
FACE CURTAIN ENVELOPE
SUBJECT = VAR.
DEVICE = 1
ENVIR. = VAR.
REPET. = VAR.
Y-DISPLACEMENT (IN)
10.00
5.00
0.00
-5.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
X-DISPLACEMENT (IN)

CHART d-16

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